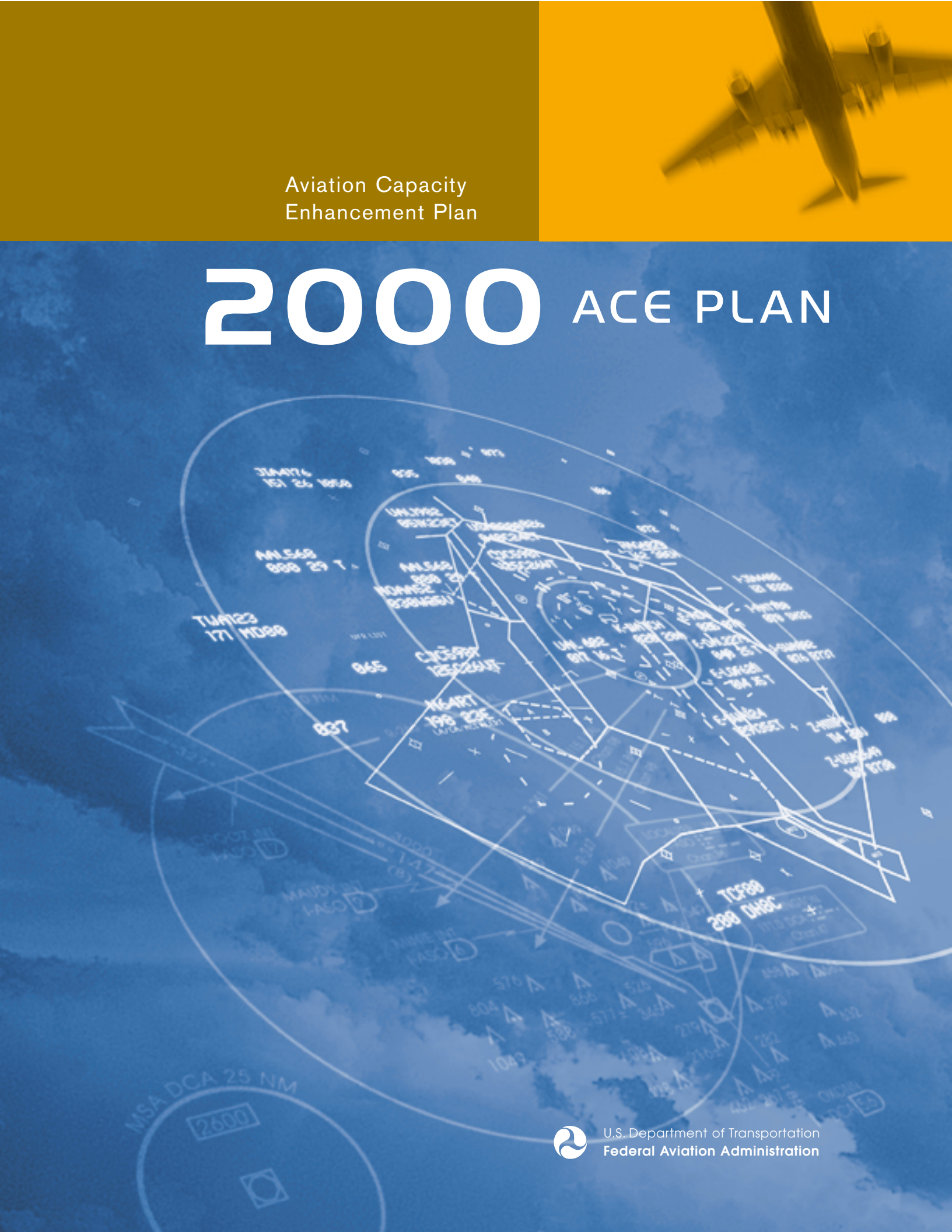
Aviation Capacity
Enhancement Plan

2000 ACE PLAN



U.S. Department of Transportation
Federal Aviation Administration

2000

AVIATION CAPACITY ENHANCEMENT PLAN

FEDERAL AVIATION ADMINISTRATION
OFFICE OF SYSTEM CAPACITY

DECEMBER 2000

Prepared jointly by the Federal Aviation Administration
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PREFACE

The Aviation Capacity Enhancement (ACE) Plan is published annually by the Federal Aviation Administration's (FAA) Office of System Capacity (ASC). The ACE Plan is a reference guide to new and on-going Agency initiatives to expand airport and airspace capacity. The ACE Plan is comprised of the following chapters:

Chapter 1 — Regional Jets Reshape A Dynamic Industry
Provides an overview of the rapid growth of regional jets and their impact on the National Airspace System, including aircraft performance comparisons, a historic perspective on changes in the aviation industry and a summary of their anticipated impact on airport design.

Chapter 2 — Elements of the National Airspace System
Describes the fundamental elements of the National Airspace System, includes information on airports, air traffic facilities and equipment, navigational aids, and airways.

Chapter 3 — National Airspace System Activity and Sources of Demand
Contains current activity and demand in the National Airspace System and provides estimates of future demand.

Chapter 4 — Capacity of the National Airspace System
Discusses the factors affecting airspace and airport capacity.

Chapter 5 — Improving System Performance
Provides an overview of the FAA's strategies to improve system performance.

Chapter 6 — Airport Development
Contains an overview of airport development, including ownership, governance, and an update on construction projects.

Chapter 7 — Airspace Design
Summarizes the FAA's efforts to improve airspace capacity by redesigning airspace.

Chapter 8 — Operational Procedures
Offers an update on air traffic control procedures, part of the ongoing effort to increase capacity with little or no investment in airport infrastructure or equipment.

Chapter 9 — National Airspace System Modernization
Contains an overview of the FAA's progress towards modernization of the National Airspace System through 2015.

The chapters are supported by additional information on aviation activity and construction projects at the 100 busiest U.S. airports in a series of appendices:

Appendix A
Provides historical, current, and forecast information on aircraft operations and passenger enplanements.

Appendix B
Summarizes the status of the recommendations of completed Capacity Enhancement Plans.

Appendix C
Summarizes runway construction projects that are proposed or planned for 2006 and beyond.

Appendix D
Presents airport layouts highlighting current capacity enhancement projects. This year a new feature includes traffic activity graphs as part of the layouts.

Appendix E
Defines acronyms used in the ACE Plan.

Appendix F
Lists the references used to prepare the ACE Plan and credits for materials from FAA and non-FAA sources.

INTRODUCTION

INTRODUCTION

The image on the cover of the ACE Plan captures the depth and complexity of operating in the National Airspace System (NAS). Two perspectives are depicted: an air traffic control radar scope that shows several aircraft in a controller's airspace, and the approach plate that a pilot would use when making an instrument approach to an airport within Washington Center airspace. Each layer of responsibility affects the other—controllers and pilots must work together for the air traffic control system to work.

Significant Developments

During 1999, traffic continued to grow steadily; enplanements reached 659.9 million and operations increased to 68 million. The FAA forecasts continued growth, with enplanements passing 1 billion and operations climbing to 86.9 million by 2011, increasing the need for capacity enhancements.

In April 2000, Congress passed the Wendell H. Ford Aviation and Reform Act for the 21st Century, known as AIR-21. This legislation provides the FAA with a $10 billion increase in funding over the next three years, with most of the additional funding going towards radar modernization and airport construction projects. AIR-21 also phases out slot controls at LaGuardia, Kennedy, and Chicago O'Hare airports.

Another important development was the rapid growth in regional jet operations. As the changeover of the regional airlines' fleets from turboprops to jets continues, the distribution of traffic in the NAS is also changing, affecting both airspace and airport capacity.

Capacity Enhancements Continue

Building new airports is the most direct means of improving capacity, but the FAA also works to use the existing infrastructure more efficiently. The Office of System Capacity coordinates research on improvements in runways and taxiways, navigational aids, and operational procedures. Since the start of the Airport Capacity Design Team program in 1985, 47 Airport Capacity Team studies have been completed.

Airport construction projects, depending upon the type of project, may take a decade or more to complete. Projects recently completed at the 100 busiest airports include runway extensions at Newark International and Memphis International and a new runway at Phoenix Sky Harbor International.

Delays In Perspective

In 1999, some 374,116 flights were delayed 15 minutes or more, an increase of 22 percent from 1998. A large majority of these delays were attributed to weather and a smaller but significant percentage to volume. Unfortunately, delays continued to increase through the first nine months of 2000. Figure I-1 puts these delays into perspective, showing how they are concentrated at a relatively small number of airports. Ten large-hub airports accounted for 64 percent of all delays in 1999, but only 31 percent of enplanements.

Figure I-1

Airports Ranked by Number of Delays

Rank	ID	Total Ops	Total Delays	Delays per 1,000 Ops	Average Time (Min)	CY99 Enplanements	% of Total Enplanements
1	ORD	897,290	49,202	54.83	55.83	34,050,083	5%
2	EWR	463,000	36,553	78.94	49.98	16,927,048	3%
3	ATL	909,911	32,737	35.97	37.67	38,136,866	6%
4	LGA	368,311	28,474	77.3	39.95	11,968,030	2%
5	SFO	440,032	21,187	48.14	52.96	19,249,988	3%
6	DFW	867,338	16,731	19.29	38.7	27,990,212	4%
7	BOS	502,164	14,989	29.84	43.96	13,183,145	2%
8	PHL	480,279	14,516	30.22	45.25	13,183,145	2%
9	JFK	355,677	13,547	38.08	36.44	11,762,140	2%
10	PHX	563,843	11,919	21.13	27.11	16,781,835	3%
Total ➤		**5,847,845**	**239,855**			**205,424,530**	**31%**
Total Average ➤				**43.38**	**42.79**		
Total All Airports ➤			**374,116**			**659,923,639**	

Sources: Federal Aviation Administration, Top 10 Facilities by Total Delays, CY99
Federal Aviation Administration, APO-130. Enplanements for all airports, CY99

Figure I-2 summarizes planned runway projects at the same ten airports from 2000 through 2005. In addition to the completed projects mentioned above, future plans include new runways at Hartsfield Atlanta International, Dallas/Fort Worth International and a proposed runway at Boston Logan International. Runway extensions are planned at Dallas/Fort Worth International and Phoenix Sky Harbor International.

Figure I-2

Runway Projects at the Most Delayed Airports

Rank	ID	Planned Runway Projects through 2005	Estimated Completion
1	ORD	*No Projects Planned*	*N/A*
2	EWR	Runway 4L/22R Extension	2000
3	ATL	New Runway 9S/27S	2005
4	LGA	*No Projects Planned*	*N/A*
5	SFO	*No Projects Planned*	*N/A*
6	DFW	Runway 18R/36L Extension	2002
		Runway 17C/35C Extension	2003
		Runway 18L/36R Extension	2004
		New Runway 18R/36L	2005
7	BOS	New Runway 14/32	2005
8	PHL	*No Projects Planned*	*N/A*
9	JFK	*No Projects Planned*	*N/A*
10	PHX	New Runway 7/25	2000
		Runway 8L/26R Extension	2002

Source: Federal Aviation Administration, APP-410

Improving System Performance

Beginning in the fall of 1999 and continuing through 2000, the FAA has taken significant steps to reduce delays through the Spring/Summer Plan. A joint FAA/industry effort, the Spring/Summer Plan was designed to mitigate the effects of severe weather on aircraft operations through a re-commitment to collaboration between the FAA, the airlines, and other NAS users.

The FAA continued its efforts to reduce delays when in May 2000 a group of NAS users, FAA managers, and union representatives met to discuss the National Airspace Redesign. Participants suggested that the FAA concentrate on short-term actions to improve performance at a number of system choke points. The FAA embraced these suggestions and quickly prepared a national plan to relieve the congestion at those choke points. The first action items are scheduled to be implemented or fully tested by the end of October 2000.

Milestones in NAS Modernization

NAS Modernization, the FAA's long-term plan to meet the growing demand for air traffic services had several significant accomplishments in the past year:

- The FAA dedicated the final Display System Replacement (DSR) on July 14, 2000 at the Washington Air Route Traffic Control Center (ARTCC). The first major component of the FAA's modernization of the nation's en route air traffic control system infrastructure, the DSR program was completed on time and within budget, and the new equipment is now operational at all 20 continental ARTCCs.
- The first HOST and Oceanic Computer System Replacement (HOCSR), which replaced antiquated computers, was dedicated at the New York ARTCC in March 1999. Subsequent installations proceeded rapidly and by January 2000 the new systems had been installed at all 20 continental ARTCCs.
- The five technologies of Free Flight Phase 1 were successfully deployed at test sites around the country and are bringing real and measurable improvements to air traffic control operations:
  - The User Request Evaluation Tool (URET) has increased the number of direct routes at Indianapolis and Memphis ARTCCs by approximately 30 percent
  - The Traffic Management Advisor has increased the arrival rate at Dallas/Fort Worth Airport by five percent
  - The Passive Final Approach Spacing Tool has enabled controllers to add one or two arrivals per rush at Dallas/Fort Worth Airport
  - The Surface Movement Advisor has helped airlines avoid three-to-five diversions per week at Detroit Metropolitan Airport
  - Collaborative Decision Making has helped airlines avoid over 10 million minutes of delay

Summary

The challenges posed by the continuing growth of traffic and the changes in the distribution of that traffic are real. The FAA is dedicated to meeting those challenges and the needs of the aviation community. The FAA's goal is to enhance system capacity while ensuring safety in aviation. The ACE Plan highlights the FAA's new and on-going initiatives to reach those goals.

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REGIONAL JETS RESHAPE A DYNAMIC INDUSTRY

I

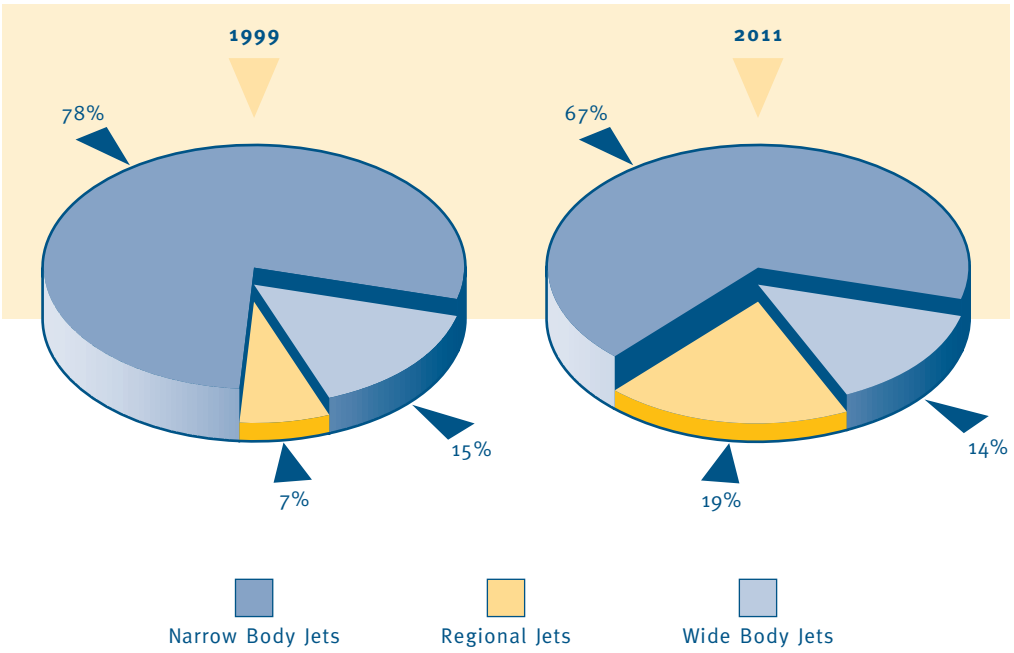
1 REGIONAL JETS RESHAPE A DYNAMIC INDUSTRY

Regional jets (RJs) are one of the most dynamic factors currently affecting the aviation industry. Their rapid growth poses both challenges and opportunities for airports, the air traffic control system, and airlines.

1.1 Market Overview

The definition of a regional jet varies among industry sources. For the purposes of this chapter, an RJ is a turbofan-powered airplane seating 100 or fewer passengers. According to FAA statistics, in 1999 there were 343 regional jets in the U.S. fleet of 4,655 commercial passenger aircraft, seven percent of the total. The FAA forecasts that by 2001 the percentage of regional jets in the fleet will nearly triple, to 19 percent. Figure 1-1 compares the percentages of narrow bodies, wide bodies, and regional jets in the fleet for 1999 and 2011.

Figure 1-1
U.S. Fleet by Aircraft Type



Regional jets are produced by a dedicated group of manufacturers that includes Bombardier, Embraer, British Aerospace, and Fairchild Dornier. In the past, jets with 35 to 50 seats have dominated the market, especially the Bombardier CRJ and the Embraer ERJ 145. However, the outlook for the most popular models is changing as RJs with greater seating capacity are developed. Bombardier is now developing the CRJ-70, with 70 seats, and Embraer is developing the ERJ 170, with 70 seats, and the ERJ 190, with 98 seats. Sales of these and other regional jets are projected to exceed $57 billion in the next decade.

Because of their growing importance, the FAA has increased its focus on the impact of regional jets on the NAS. This chapter provides an overview of some of the most important issues:

- The operational characteristics of regional jets
- The role of regional jets in the aviation industry
- How market conditions, competition, and legislation are changing the role of regional jets
- How regional jets may impact airspace and airport capacity

1.2 Operational Characteristics of Regional Jets

Regional jets are positioned between narrow body jets, such as the B-737 and the MD-80, and larger turboprops, such as the Saab 340 and the Bombardier Dash-8. The seating capacity of most regional jets in operation is comparable to that of the larger turboprops, while their performance is comparable to that of the narrow body jets. Figure 1-2 compares the seating capacity of turboprops, regional jets, and narrow body jets and Figure 1-3 compares their cruising speeds.

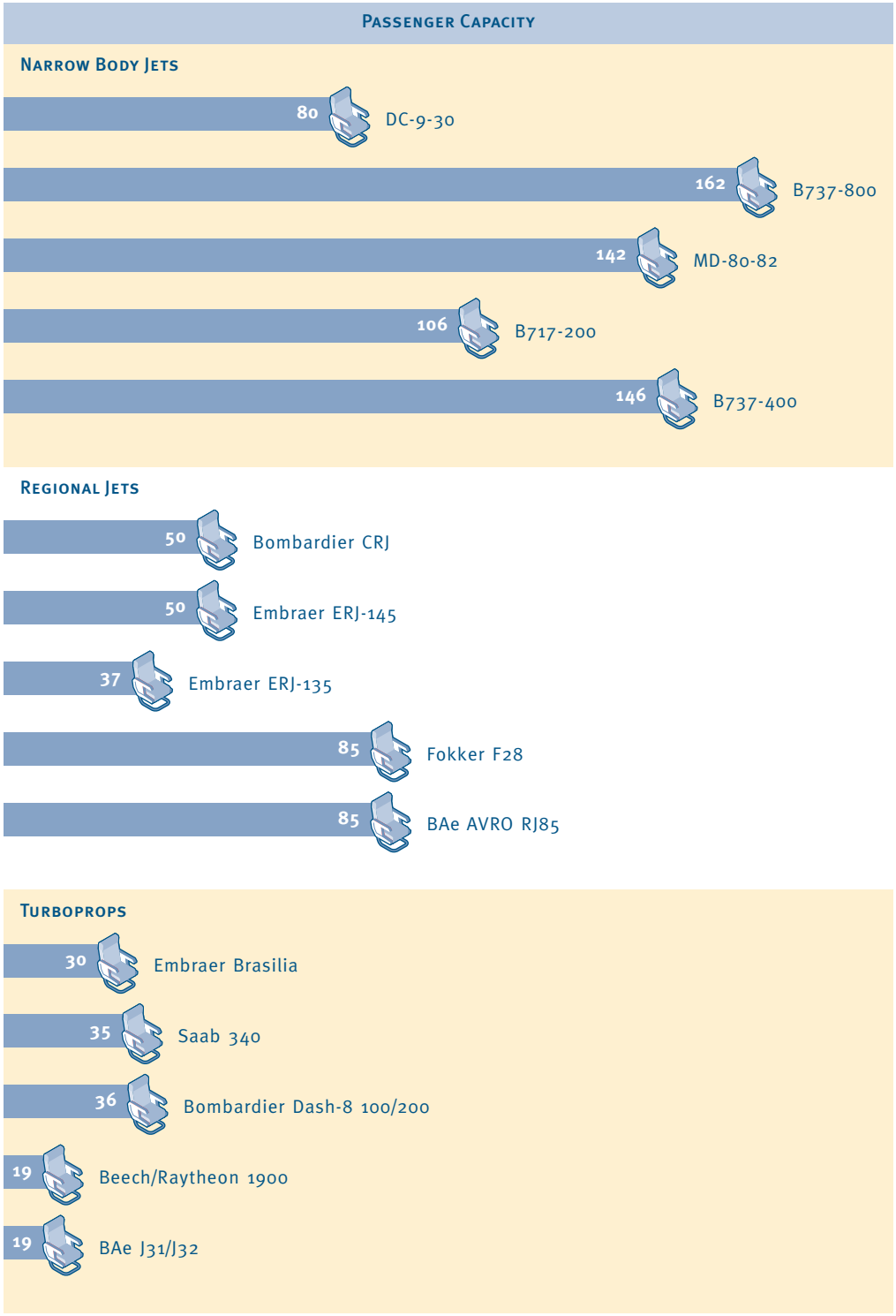
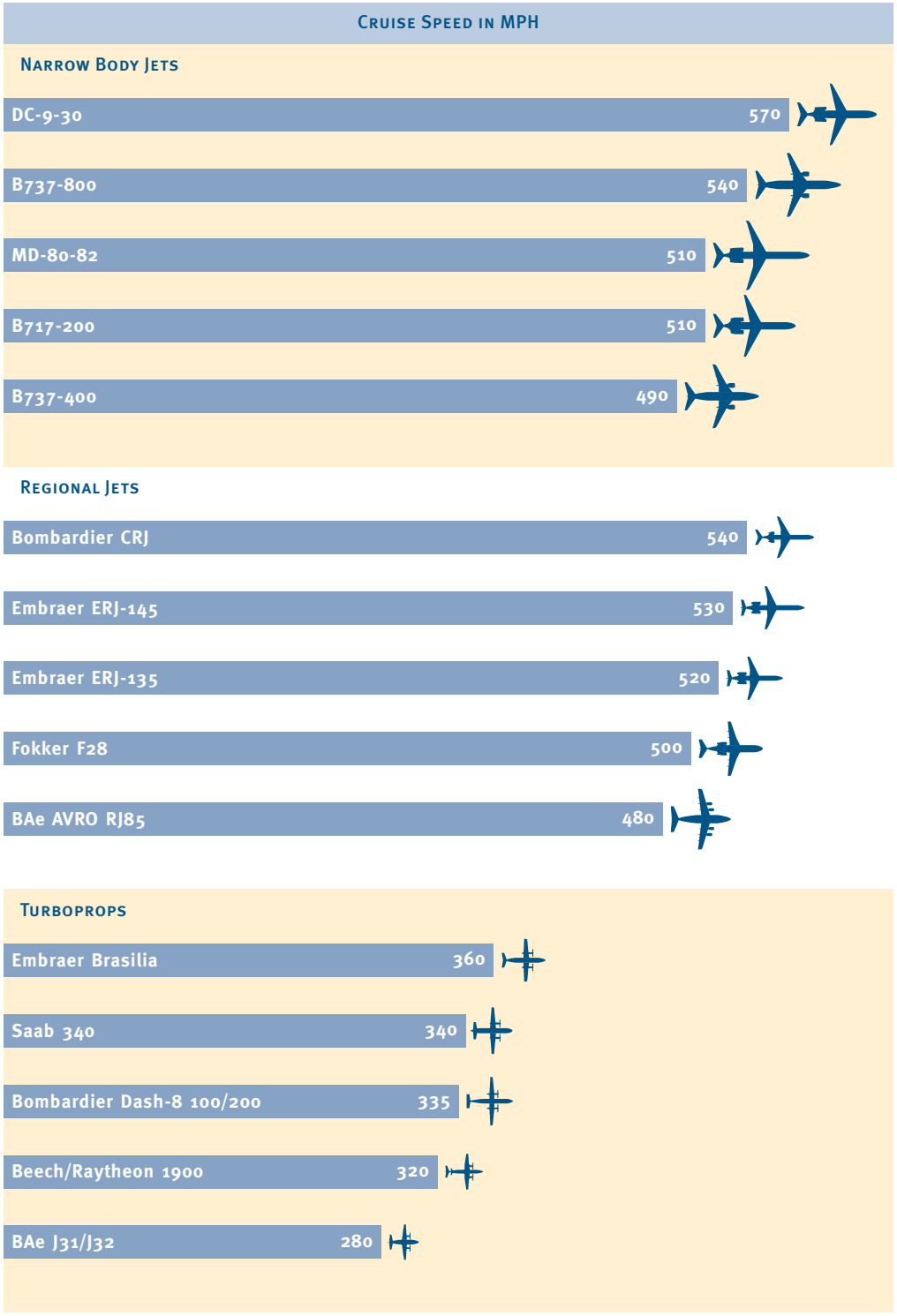


Figure 1-2
Seating Capacity of Turboprops, Regional Jets, and Narrow Body Jets

Figure 1-3

Cruising Speed of Turboprops, Regional Jets, and Narrow Body Jets



1.3 The Role of Regional Jets

The widespread use of regional jets is a relatively recent phenomenon. Air carriers are using regional jets to achieve a number of strategic objectives:

- To replace turboprop aircraft in certain markets
- To provide additional seating capacity in turboprop markets during peak traffic times
- To provide new service in existing hub-and-spoke systems (hub extension)

- To provide point-to-point service between smaller markets (hub bypass)
- To replace larger jets on routes that are marginally profitable for them, but can be profitable for regional jets
- To stimulate traffic by shifting car, rail, and bus travelers to air

Although the strategic positioning of RJs by regional and major air carriers has been important, their rapid growth can be largely attributed to their popularity among travelers. Passengers prefer regional jets because they are more comfortable, quieter in the cabin, and faster than turboprops. The replacement of turboprops is one of the factors contributing to RJ growth, but there will always be a role for turboprops. Many small communities with stable or declining populations, seasonal traffic, or airport facilities that were built for turboprops will sustain their operation. In general, the economics of routes of less than 250 miles favor turboprops, while routes of 250 to 700 miles favor regional jets.

1.4 The Changing Role of Regional Jets

During the past decade, major and regional carriers have formed strategic marketing alliances and code sharing agreements to align hub schedules and improve profits. In addition, some majors have purchased regional carriers outright and are operating them as fully-owned subsidiaries. As this trend continues, the distinction between regional carriers and major airlines is becoming increasingly blurred.

Recent legislation is also expected to foster the growth of regional jets. AIR-21 includes provisions to improve service to small communities. AIR-21 will increase access to LaGuardia, Kennedy, and O'Hare airports by phasing out slot controls. This initiative, which encourages new service to smaller communities from these airports, should affect the rate at which new regional aircraft enter the system. In particular, for airlines to qualify for new landing rights at LaGuardia, they must use regional jets. In response, a number of carriers have already initiated or announced plans to expand their regional jet service to LaGuardia. AIR-21 also creates an incentive program to help airlines buy RJs if they agree to use them to serve small airports and establishes an Air Service Development program for small-hub and non-hub airports.

AIR-21 also includes provisions to maintain the integrity of the Essential Air Service (EAS) program. Initially established by the Deregulation Act of 1978, EAS maintains subsidized air service to smaller communities. Since 1978, the number of communities that receive EAS funding has increased from 322 to 499. The continuation of EAS subsidies will maintain service to small communities that are primarily served by piston aircraft, turboprops, and smaller regional jets.

Although most forces are stimulating RJ growth, their continued expansion and the rate of their integration into the NAS may be slower than predicted. Factors that could hinder RJ growth include saturated airport and ATC capacity, increased regulatory costs, environmental issues, and labor concerns such as scope clauses.[1]

1.5 The Impact of Regional Jets on Airspace Capacity

The increased use of regional jets is changing the distribution of traffic in both en route and terminal airspace. Regional jets can fly at higher (and more fuel-efficient) altitudes than turboprops. As RJs replace turboprops, the number of aircraft using high altitude airspace on certain routes may increase, straining airspace capacity at higher altitudes and reducing

1 Most contracts between major airlines and their pilot groups contain scope clauses that limit the number and type of regional jets that a carrier or its affiliates can operate.

traffic at lower altitudes. At the same time, when RJs are used in place of larger jets to bypass hubs, high altitude airspace on some currently congested routes may be freed up.

In terminal airspace, replacing turboprops with RJs may lead to an increase in traffic complexity, which would reduce controllers' options, especially during peak traffic periods. For example, controllers frequently assign departing turboprops divergent headings from those of jet aircraft, since they will use a different altitude or route to exit terminal airspace. This procedure increases departure runway capacity, since large in-trail separations are not required. However, as regional jets replace turboprops, the opportunity to use divergent headings may be reduced. Another air traffic procedure that controllers have used with turboprops, land and hold short (LAHSO), is not an option for regional jets at certain airports because they require a longer distance to stop, so they can land but cannot hold short of intersecting runways.

1.6 The Impact of Regional Jets on Airport Capacity

Regional jets require longer runways than turboprops, generally at least 6,000 feet, although runway requirements vary among RJ models. According to FAA records, there are 35 runways that are less than 6,000 feet long at large and medium hub airports, including Washington Reagan National, Philadelphia International, Chicago Midway, and Raleigh-Durham International.

Runway length requirements also depend upon the elevation, temperature, payload, and flight distance. In particular, RJ flights of less than 500 miles may be able to land safely on runways that are shorter than the published requirements for fully loaded aircraft. Since the average RJ flight in 1998 was only 375 nautical miles, many RJ flights will be able to use runways that are shorter than 6,000 feet. As Figure 1-4 indicates, the runway length requirements for the most popular regional jets for flights of 500 nautical miles are well below this threshold.

Figure 1-4
Runway Length Requirements for Regional Jets

Aircraft	Range (NM)	RLR for Maximum Range Flight ISA*	RLR for Maximum Range Flight ISA + 15°C**	RLR for 500 NM Flight ISA +15°C**
CRJ 100	1,760	6,100 ft	6,800 ft	5,200 ft
CRJ 200	1,920	6,300 ft	7,000 ft	5,000 ft
ERJ 135	1,420	5,250 ft	5,540 ft	4,430 ft
ERJ 145	1,620	6,460 ft	6,730 ft	5,810 ft

* International Standard Altitude (ISA) at sea level.
** ISA plus 15°C is equivalent to 86°F.

In general, for those airports that were built or modified for jet operations, RJs will require only limited, if any, modifications. However, the ability of those airports to accommodate an increased number of regional jets depends on its current capacity level. A small, under-utilized airport designed for commercial jet operations may be able to easily accommodate additional RJ flights. A large airport may be limited in its ability to add RJ operations if it is already congested and relies on shorter runways for turboprop operations.

The introduction of RJs to airports that were not designed to handle jets may require significant modifications. A recent FAA study evaluated the impact of regional jets on airport design issues,[2] and concluded that:

- Runways that meet the standards for crosswinds for turboprops will also meet the standards for RJs
- Airports whose taxiway systems support turboprop operations should also meet the requirements of RJs
- RJs will not affect runway-to-runway separations
- RJs will not affect Obstacle Free Zone dimensions
- Airports that were designed to accommodate only turboprops may need to make modifications to account for the effects of jet blast
- FAA standards for the dimensions of Runway Safety Areas, the safety zone surrounding the runway, will increase where RJs replace turboprops
- FAA standards for the dimensions of Runway Protection Zones, the buffer between an airport and the surrounding communities, will increase when RJs replace turboprops

1.7 Summary

Most aviation analysts expect the size of the regional jet fleet, the number of RJ operations, and the number of airports they serve to continue to grow rapidly for the foreseeable future. Although the cyclical nature of the airline industry makes it impossible to predict trends with certainty, it is clear that regional jets will continue to drive changes in airport and airspace use. The FAA will continue to work with the industry to develop new infrastructure and air traffic management procedures to ensure the continued safe and efficient operation of regional jets in the NAS.

2 Kenneth C. Jacobs, *The Impact of Regional Jets on Airport Design,* Airport Design Division (AAS-100), Federal Aviation Administration.

ELEMENTS OF THE NATIONAL AIRSPACE SYSTEM

2

2 ELEMENTS OF THE NATIONAL AIRSPACE SYSTEM

The National Airspace System is an interconnected system of airports, air traffic facilities and equipment, navigational aids, and airways. These elements of the NAS are operated and supported by airport employees, air traffic controllers, technicians, airspace specialists, and others.

Airports, air traffic facilities and equipment, and navigational aids are static physical components of the NAS. Over longer periods, airports may be expanded as new runways, taxiways, and terminal buildings are built; new air traffic facilities may be built and air traffic equipment and navigational aids modernized. In contrast, the condition of the airways changes continuously, as they are affected by changing weather, winds, and traffic. This chapter describes both the static and dynamic elements of the NAS.

2.1 Airports in the United States

Although there are more than 19,000 airports in the United States, over 5,000 of which are open to the public, the FAA considers only 3,367 to be significant to the capacity of the NAS. These airports are included in the National Plan of Integrated Airport Systems (NPIAS) and are eligible to receive Federal grants under the Airport Improvement Program (AIP). Within the NPIAS, the airports are divided into two major categories: commercial service airports and general aviation airports.

2.1.1 Commercial Service Airports

Commercial service (CS) airports are public airports receiving scheduled passenger service and having 2,500 or more enplaned passengers per year (an enplaned passenger is a passenger on a scheduled or unscheduled commercial flight). Figure 2-1 shows the classifications of the 546 commercial service airports as well as the percentages of enplaned passengers for each class. The 422 airports that have more than 10,000 annual enplanements are classified as primary airports. Those commercial service airports enplaning from 2,500 to 10,000 passengers annually are classified as “other” commercial service airports.

Within the primary airport classification, the term “hub” is used to identify very busy commercial service airports. This use of the term hub is different from that used in the airline industry, where a hub is an airport where passengers connect with other flights coming from the spokes of the system. The NPIAS term does not differentiate between airports with mostly connecting traffic and those with mostly origin-destination traffic. The primary airports are divided into large-hub, medium-hub, small-hub, and non-hub airports, based on the number of annual enplanements. Large-hub airports are those that account for at least one percent of total U.S. passenger enplanements. Medium hubs are airports that account for between 0.25 percent and one percent of total passenger enplanements and small hubs from 0.05 percent to 0.25 percent of total passenger enplanements. Commercial service airports that enplane less than 0.05 percent of total passenger enplanements but more than 10,000 annually are classified as non-hub primary airports.

Type of Airport	Number of Airports	Definition of Airport Type	Percentage of Enplanements
Large-Hub	31	At least 1% of passenger enplanements	69.6%
Medium-Hub	37	0.25% to 1% of passenger enplanements	19.3%
Small-Hub	72	0.05% to 0.25% of passenger enplanements	7.7%
All Hub Airports ➤	**140**	**More than 0.05% of passenger enplanements**	**96.6%**
Non-Hubs	282	Less than 0.05% of passenger enplanements	3.2%
All Primary Airports ➤	**422**	**More than 10,000 passenger enplanements**	**99.8%**
Other CS Airports	124	2,500 to 10,000 passenger enplanements	0.1%
All CS Airports ➤	**546**	**More than 2,500 passenger enplanements**	**99.9%**

Figure 2-1
Commercial Service (CS) Airports in the U.S.

The number of large-hub, medium-hub and small-hub airports can vary from year to year because the classification is based on a percentage of total passenger enplanements rather than a fixed number. For example, from 1998 to 1999 the number of large hubs increased from 30 to 31 because enplanements at Ft. Lauderdale grew more rapidly than did total passenger enplanements, moving it above the one percent threshold. In the same period, the number of medium hubs decreased from 42 to 37, the number of small hubs increased from 70 to 72.

Traffic in the United States is concentrated at the largest airports. Figure 2-1 also shows the percentage of total passenger enplanements for each airport type. The 31 large-hub airports accounted for 69.6 percent of total passenger enplanements in 1999, the 37 medium-hub airports for 19.3 percent, and the small hubs for another 7.7 percent (the140 hub airports had 96.6 percent of total passenger enplanements). The remaining 282 primary airports had only 3.2 percent of enplanements, while the 128 non-primary commercial service airports accounted for only 0.1 percent of enplanements.

2.1.2 General Aviation Airports

Airports that have less than 2,500 annual enplanements or do not receive any scheduled commercial service are considered general aviation airports. They are included in the NPIAS if they account for enough activity (generally defined as having at least ten based aircraft) and are at least 20 miles from the nearest NPIAS airport. Figure 2-2 shows the classes and numbers of general aviation airports and the percentage of total based aircraft at each.

Type of Airport	Number of Airports	Percentage of Based Aircraft
Relievers	315	33%
GA › 50 Based Aircraft	438	22%
GA › 25 Based Aircraft	584	11%
GA › 10 Based Aircraft	777	7%
GA ‹ 10 Based Aircraft	707	2%
All GA Airports ➤	**2,821**	**75%**

Figure 2-2
NPIAS General Aviation Airports in the U.S.

The 2,821 NPIAS general aviation airports are divided into reliever and general aviation airports. Relievers are high capacity general aviation airports in major metropolitan areas that provide general aviation pilots and aircraft with attractive alternatives to using congested commercial service airports. There were 315 relievers in 1999, including important airports such as Merrill Field in Anchorage, Alaska; Teterboro Airport in New Jersey near New York City; and Van Nuys in California. The remaining 2,506 general aviation airports generally serve rural areas, and have very little, if any, commercial service.

Although relievers and other general aviation airports have little commercial service, they do have a small number of passenger enplanements, primarily provided by air taxi operators. In 1999, 1,780 general aviation airports had some enplanements totaling only 0.1 percent of total passenger enplanements.

2.2 Airspace in the United States

Airspace in the United States is managed by the FAA to provide for its orderly and safe use. The NAS includes all airspace over the United States from 60,000 feet down to, but not including, the ground. Over the years, the FAA has promulgated numerous regulations that divide the airspace into different classifications and provide complex rules for operating within each classification.

2.2.1 Classes of Airspace

The national airspace is divided into two broad categories, controlled (Classes A through E airspace) and uncontrolled (Class G airspace). Within these two categories, there are a number of classifications that determine the flight rules, pilot qualifications, and aircraft capabilities required to operate within any section of the airspace. The specific classification of any area is broadly based on the complexity and density of aircraft movements, the nature of operations conducted within the airspace, the level of safety required, and the national and public interest. The six classes of U.S. airspace are described below and are depicted in Figure 2-3.

Class A Airspace

All airspace from 18,000 Mean Sea Level (MSL) to 60,000 MSL, including the airspace overlying the waters within 12 nautical miles of the coast of the contiguous 48 states and Alaska. All operations within Class A airspace must be under Instrument Flight Rules and are under the direct control of FAA controllers. Class A airspace always starts at 18,000 MSL and it is not specifically charted.

Class B Airspace

Airspace surrounding the nation's busiest commercial service airports. At its core it extends from the surface up to 10,000 MSL. Class B airspace is charted on sectional charts, IFR en route (low altitude) charts, and terminal area charts.

Class C Airspace

Airspace surrounding airports of mid-sized cities with a large number of commercial flight operations; it extends from 700 feet Above Ground Level (AGL) to 4,000 AGL. An operating control tower at the primary airport and radar services are key components of Class C airspace.

Class D Airspace

This airspace is applied to airports with operating control towers where the traffic volume does not meet Class C or Class B standards. This area encompasses 700 AGL to 2,500 AGL.

Class E Airspace

Includes all airspace from 14,500 MSL up to, but not including 18,000 feet MSL. Class E airspace also includes all other controlled airspace necessary for IFR operations at lower altitudes but not already classified as A, B, C, or D. This includes features such as low level airways (victor airways) and IFR transition areas.

Class G Airspace

Class G airspace is uncontrolled airspace and includes all airspace not otherwise designated as A, B, C, D, or E. Operations within Class G airspace are governed by the principle of "see and avoid."

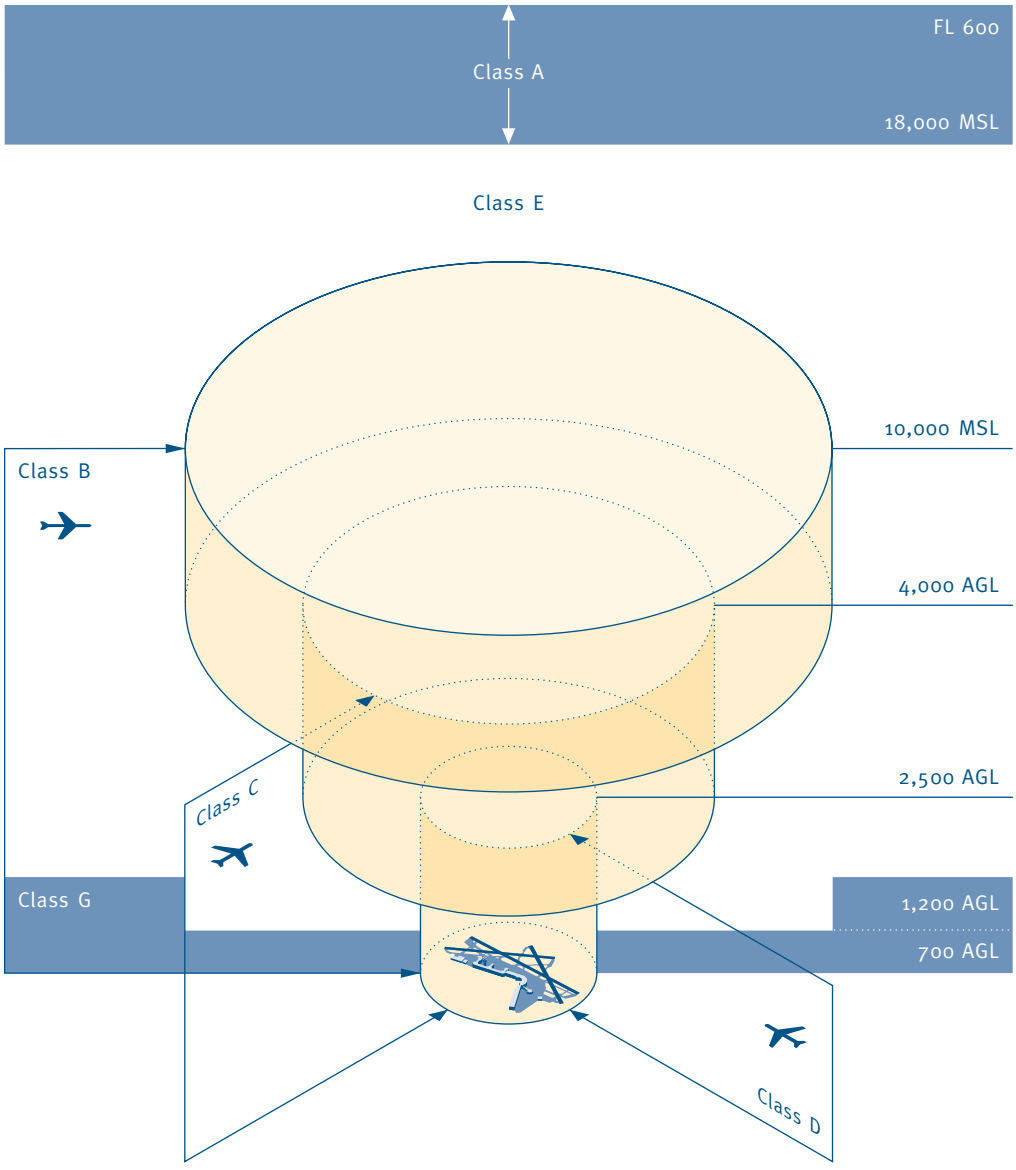


Figure 2-3
Classes of Airspace

En route airspace in the United States consists of several routing corridors used by both IFR and VFR traffic. Traffic is concentrated along these routes. Low altitude airways, termed victor airways, are the primary routes used by both IFR and VFR traffic. They are eight nautical miles wide and generally go from 1,200 feet above ground level up to, but not including, 18,000 MSL. The airway floor may be higher in areas of the western U.S. where terrain interferes more with the navigational facilities upon which the airways are based. They are depicted on aeronautical charts as blue shaded lines with a "V" (hence the term victor), followed by a number, such as V500, and are found on the sectionals, IFR en route low altitude charts, and terminal area charts.

Jet routes serve the same function as the low altitude airways except that they are found at 18,000 MSL and above (up to 45,000 MSL). Traffic on the jet routes is always IFR and is managed by air traffic control. Jet routes are shown on high altitude charts as a gray line and are designated by the letter "J," followed by a number, such as J547.

2.2.2 Special Use Airspace

Special use airspace (SUA) is designed to segregate flight activity related to military and national security needs from other airspace users. Although most SUAs involve military activity, others involve civilian users such as the Department of Energy or the U.S. Secret Service. Special Use Airspace is established by the FAA, usually at the request of the affected civilian agency or military branch. There are six different kinds of special use airspace: Prohibited Areas, Restricted Areas, Military Operations Areas, Alert Areas, Warning Areas, and Controlled Firing Areas.

Prohibited Areas

Prohibited areas are established over sensitive ground facilities such as the White House, presidential homes, and Camp David. All aircraft are prohibited from flight operations within a prohibited area unless specific prior approval is obtained from the FAA or the controlling agency.

Restricted Areas

Restricted areas are established in areas where ongoing or intermittent activities occur that create unusual hazards to aircraft, such as artillery firing, aerial firing, and missile testing. Restricted areas differ from prohibited areas in that most of them have specific hours of operation. Entry during those hours requires specific permission from the FAA or the controlling agency.

Military Operations Areas

Military Operations Areas (MOA) are established to contain certain military activities, such as air combat maneuvers, intercepts, and acrobatics. Civilian flights are allowed within an MOA even when the area is in use by the military. Air traffic control will provide separation services to IFR traffic.

Alert Areas

Alert Areas contain a high volume of pilot training or an unusual type of aerial activity, such as helicopter activity near oil rigs, which could present a hazard to other aircraft. There are no special requirements for operations within alert areas other than heightened vigilance.

Warning Areas
Warning areas contain the same kind of hazardous flight activity as restricted areas (artillery firing, aerial gunnery, etc.), but are located over domestic and international waters. Warning areas generally begin three miles offshore.

Controlled Firings Areas
Controlled firing areas contain civilian and military activities that could be hazardous to non-participating aircraft, such as rocket testing, ordinance disposal, and blasting. They are different from prohibited and restricted areas in that radar or a ground lookout is used to indicate when an aircraft is approaching the area, at which time all activities are suspended.

2.3 Air Traffic Control Facilities and Equipment

Air traffic control specialists ensure that air traffic moves safely and efficiently through the NAS. That traffic includes not only commercial flights, but also corporate, military, and general aviation flights.

Air traffic control is accomplished by three general classes of controllers, each resident in different types of facilities and responsible for a different phase of flight. First, ground and local controllers at Air Traffic Control Towers at airports handle aircraft from the gate to the taxiway and runway, through the takeoff, and at the other end of the flight, from landing back to the gate. Second, radar controllers at the Terminal Radar Approach Control facilities handle aircraft from takeoff to a cruising altitude at the origin (departure control) and return them through their approach at the destination (approach control). Third, en route controllers working at Air Route Traffic Control Centers manage the flow of traffic along the airways between the terminal areas. The overall flow of aircraft across the entire United States is managed by the Air Traffic Control System Command Center in Herndon, Virginia. In addition, flight service stations provide important pre-flight and in-flight services to general aviation pilots. The functions of each of these air traffic control facilities are described briefly below.

2.3.1 Air Traffic Control Towers

Air Traffic Control Towers (ATCT) at more than 400 airports control the effective movement of traffic both on the ground and in the air within approximately five nautical miles of the airport and up to an altitude of 3,000 feet. Air traffic controllers rely on a combination of technology and visual surveillance to direct aircraft departures and approaches, maintain safe distances between aircraft, and communicate weather-related information, clearances, and other instructions to pilots.

2.3.2 Terminal Radar Approach Control Facilities

Over 185 Terminal Radar Approach Control (TRACON) facilities sequence and separate aircraft as they approach and depart major metropolitan areas. TRACONs typically control air traffic within a 30-mile radius and less than 15,000 feet altitude, exclusive of ATCT airspace.

The traffic within terminal airspace consists mostly of takeoffs and landings to and from the airports in its area, but also includes air traffic that is overflying the area. Terminal airspace is divided into sectors that can be modified, based on the runway configurations in use by the airports within that TRACON's airspace.

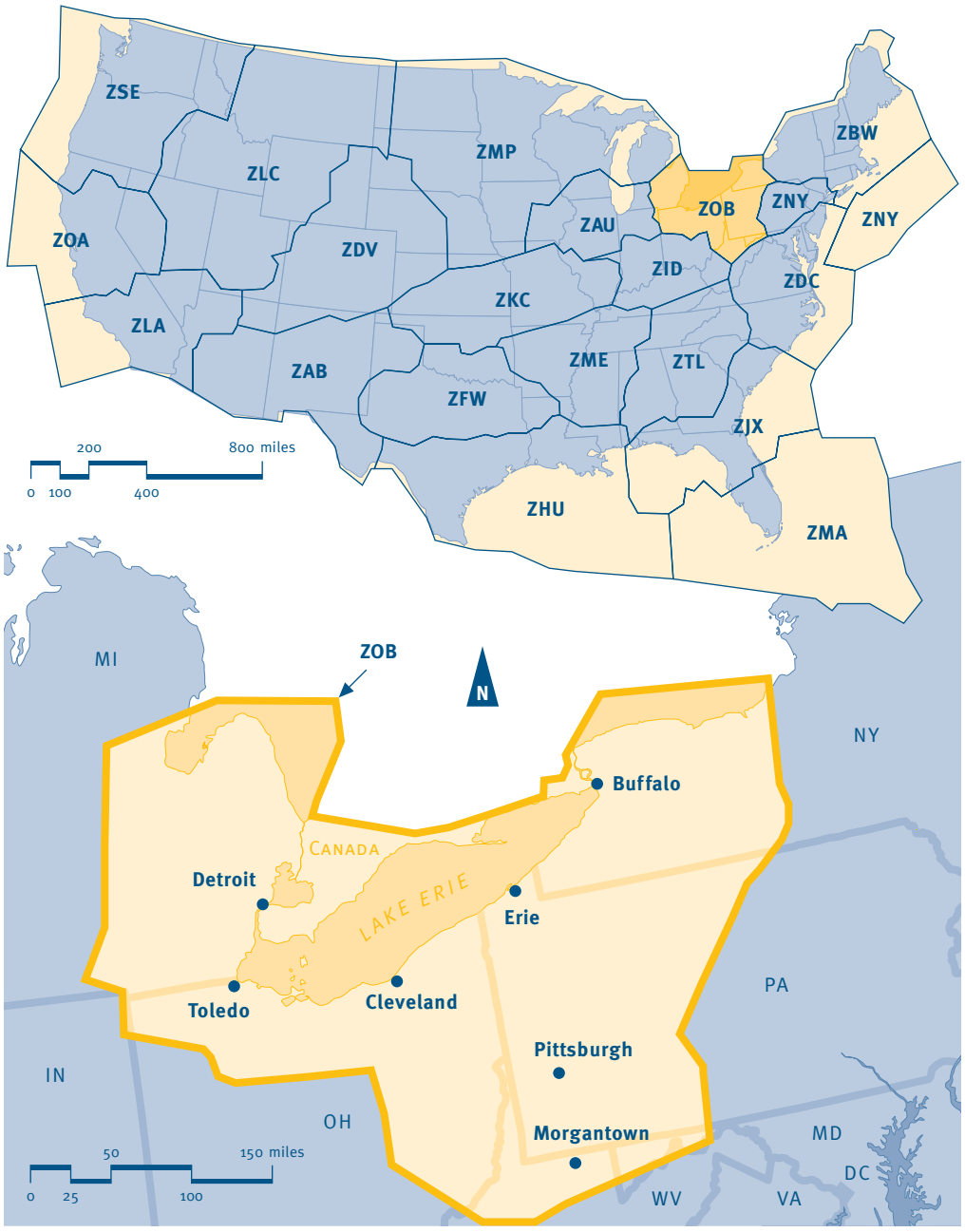
2.3.3 Air Route Traffic Control Centers

Twenty-one Air Route Traffic Control Centers (ARTCCs) control and monitor aircraft in transit over the United States and during approaches to some airports. Each en route center handles a different region of airspace, passing control from one to another as respective borders are reached until the aircraft reaches TRACON airspace or leaves U.S. airspace.

Three ARTCCs—Oakland, New York and Anchorage—also control aircraft over the ocean. Outside radar range, which extends only 175 to 225 miles offshore, controllers must rely on periodic radio communication of position reports to determine an aircraft's location.

Figure 2-4 shows the boundaries of the 20 continental ARTCCs and the airspace each controls (the Anchorage ARTCC is not shown.) The centers are designated by a three-letter code that begins with Z; for example, the Cleveland center is designated ZOB.

Figure 2-4
Airspace Managed by Centers



The size of the airspace managed by a center varies substantially, but typically consists of tens of thousands of square miles extending over several states. The Cleveland ARTCC, physically located in Oberlin, Ohio, just outside of Cleveland, controls approximately 70,000 square miles of airspace in six states and Canada. Figure 2-4 highlights the boundaries of the Cleveland ARTCC airspace.

An ARTCC's airspace is divided into sections of airspace called sectors. Sectors have vertical as well as horizontal boundaries. A few sectors extend from the ground up, but most are stratified, with the lowest sectors defined from the ground to 23,000 feet and another sector from 24,000 feet up (in some cases, a third sector may be defined for 37,000 feet and up). Figure 2-5 shows the boundaries of the Cleveland ARTCC's high altitude sectors.

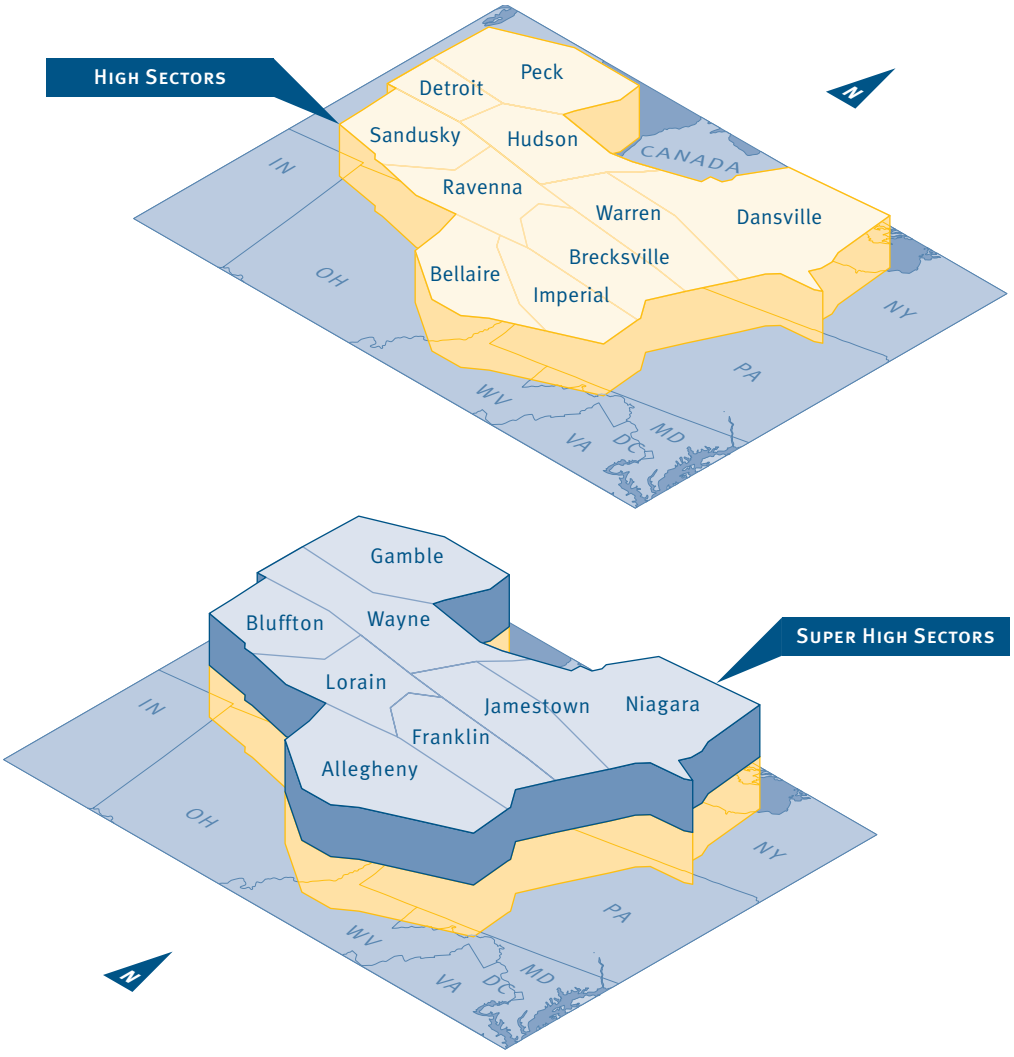


Figure 2-5
Boundaries of ZOB High Altitude Sectors

2.3.4 Air Traffic Control System Command Center

The Air Traffic Control System Command Center (ATCSCC) in Herndon, Virginia monitors traffic flows across the United States and communicates with other air traffic facilities and airline operating centers to minimize congestion and delays due to adverse weather, equipment outages, closed runways, and other capacity-related circumstances. The ATCSCC is one of the key parts of the FAA's evolving plan for management of an ever-increasing amount of air traffic. This role is highlighted in the Spring/Summer Plan.

2.3.5 Flight Service Stations

The air traffic control specialists at flight service stations provide pre-flight and in-flight services to pilots, primarily those in general aviation. The specific services provided include flight plan filing; preflight and en route weather briefings that include the status of navigational aids; airport condition reports; search and rescue operations; assistance to lost or disoriented aircraft pilots; provision of instrumental flight rule and special visual flight rule clearances, soliciting pilot reports on flying conditions, and providing special services such as customs and immigration. Pilots can receive these services by visiting a flight service station, by telephone, or through air-to-ground communications. The flight service stations also provide a weather briefing and flight plan processing service through the Direct User Access Terminal Service (DUATS), which can be accessed via toll-free telephone service.

2.4 Navigational Aids

An extensive network of facilities, generally known as navigational aids, or navaids, supports aircraft movement in the NAS. Pilots use en route navaids to guide aircraft from the vicinity of one airport to another. A typical en route navaid is the very high frequency omnidirectional range (VOR), which provides magnetic bearing information so that a pilot can determine the aircraft's position relative to the transmitter or its absolute position through triangulation with another en route navaid. There are approximately 1,026 VORs in the NAS.

Other navaids help a pilot descend from cruising altitude to land on an airport runway. The instrument landing system (ILS), which consists of a localizer for horizontal guidance and a glideslope for vertical guidance, provides instrument approach capability to the runway during low visibility. The localizer is placed beyond the stop end of the runway, aligned with the centerline. The glideslope is located beside the runway, near the touchdown point. An ILS may be certified as Category (CAT) I, II, or III, depending on its equipment configuration and system capabilities. There are currently 1,248 ILSs in the NAS. Of these, approximately 95 are approved for CAT II and/or III operations (because each runway needs a separate ILS to support instrument operations in low visibility, these 95 ILSs provide this capability at only 73 airports.) Lighting systems, such as the precision approach path indicator (PAPI) and runway end identification lights (REIL), are navaids that provide pilots with visual cues to assist them in making safe approaches and landings.

The FAA is transitioning from this system of ground-based navaids to a satellite-based system called the global positioning system (GPS). The basic GPS system is already being used by pilots for navigation in oceanic and en route airspace. Differential GPS will augment, and eventually replace, many of the ground-based navaids discussed above. The FAA anticipates that the GPS wide area augmentation system (WAAS) will provide en route, terminal, non-precision approach and selected CAT I precision approach capability throughout the NAS. The GPS local area augmentation system (LAAS) will provide CAT II and III precision approach and landing capability.

NATIONAL AIRSPACE SYSTEM ACTIVITY AND SOURCES OF DEMAND

3

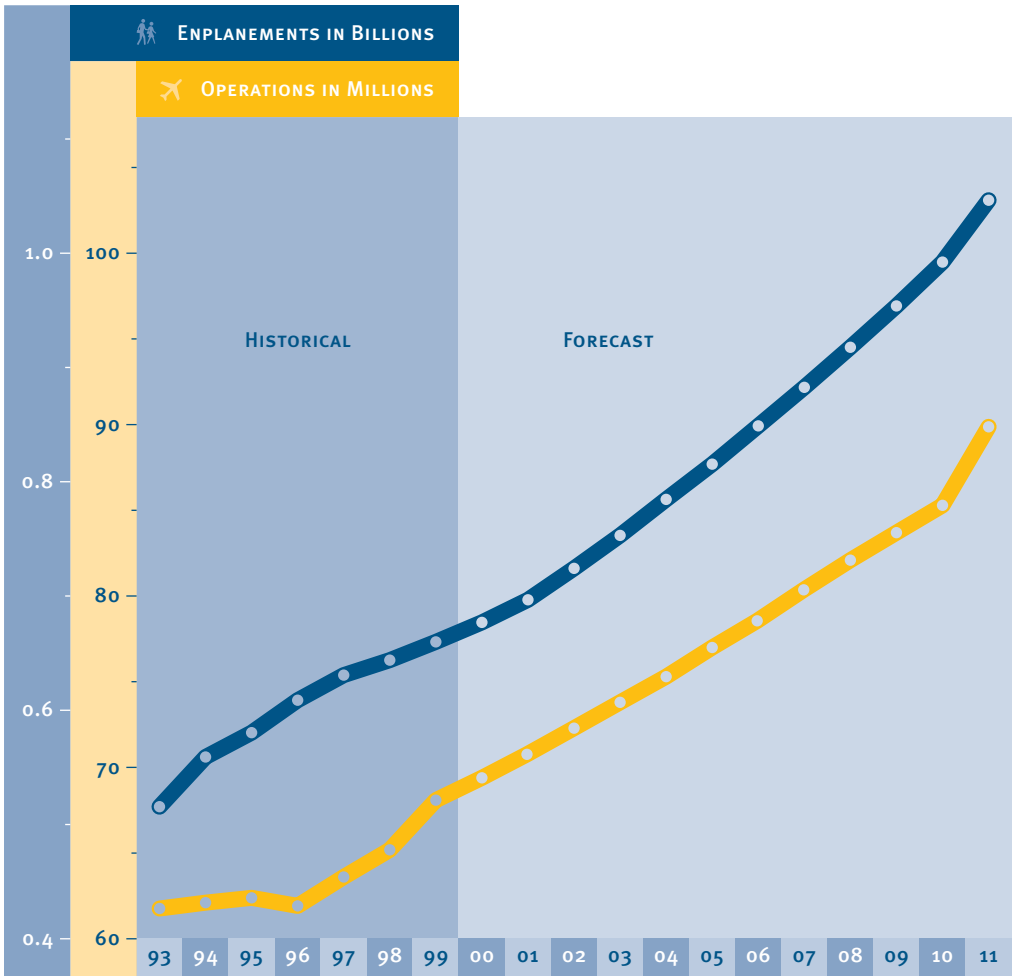
3 NATIONAL AIRSPACE SYSTEM ACTIVITY AND SOURCES OF DEMAND

Aviation activity in the United States involves a number of diverse participants: large commercial air carriers, regional/commuter airlines, the military, and general aviation operators. Passenger enplanements, aircraft operations, and air cargo tonnage are all indicators of aviation activity. This chapter provides statistics on current and projected aviation activity, and describes significant developments in the sources of demand.

3.1 Passenger Enplanements and Aircraft Operations

In FY 1999, passenger enplanements grew by 2.6 percent to 659.9 million, following the growth of the U.S. economy. In the same period, the number of aircraft operations rose by 4.1 percent to 68 million. The FAA forecasts that enplanements will top one billion for the first time in 2010 and reach 1.046 billion in 2011, an increase of 59 percent over 1999. Operations are forecast to reach 86.9 million in 2011, an increase of 28 percent over the 12-year period. Figure 3-1 shows the trend in passenger enplanements and aircraft operations from 1994 through 2011.[3]

Figure 3-1
Enplanements and Operations, FY 1994-2011



3 Most FAA statistics and all forecasts are reported by fiscal year. The ACE Plan reports activity statistics by fiscal year to facilitate comparisons with the forecasts. Figures that report calendar year data are specifically identified as such.

3.1.1 Enplanements and Operations at the Busiest Airports

Enplanements and operations for the busiest 100 airports in the U.S., as measured by 1999 passenger enplanements, are shown in Appendix A. Because of the concentration of commercial traffic at larger airports and the dispersion of general aviation operations across a wide range of airports, those 100 airports accounted for more than 96 percent of total passenger enplanements, but only 42 percent of total aircraft operations. The number of enplanements at the 100 busiest airports increased from 609.9 million in 1998 to 634.8 million in 1999, a 4.1 percent increase. In the same period, operations at the 100 busiest airports increased by 3.3 percent, from 27.5 to 28.4 million. The FAA forecasts that enplanements at these airports will grow to 994.2 million in 2011 (an increase of 57 percent) and that operations will increase to 36 million (up 27 percent).

The concentration of traffic at the largest airports is highlighted in Figures 3-2 and 3-3, which show the busiest ten U.S. airports during 1999, as measured by enplanements and operations, respectively, and the FAA forecasts for the same airports in 2011. The busiest ten airports accounted for 35.5 percent of total passenger enplanements in 1999 and only 9.7 percent of total aircraft operations. The FAA forecasts growth in both enplanements and operations at these ten airports to keep pace with national trends.[4]

ID	Airport Name	FY 1999	FY 2011	Percent Growth
ATL	Hartsfield Atlanta International	37,606,932	60,849,000	61.8%
ORD	Chicago O'Hare International	34,418,016	50,335,000	46.2%
LAX	Los Angeles International	30,436,893	46,468,000	52.7%
DFW	Dallas/Fort Worth International	28,074,665	45,224,000	61.1%
SFO	San Francisco International	19,262,805	27,486,000	42.7%
DEN	Denver International	18,148,611	27,237,000	50.1%
DTW	Detroit Metropolitan Wayne County	16,910,175	28,412,000	68.0%
EWR	Newark International	16,794,443	25,012,000	48.9%
MIA	Miami International	16,561,634	28,246,000	70.6%
PHX	Phoenix Sky Harbor International	16,316,300	28,327,000	73.6%
	Total ➤	**234,532,473**	**367,598,011**	**56.7%**

Figure 3-2

Ten Busiest U.S. Airports by Enplanements FY 1999 and Forecast for FY 2011

ID	Airport Name	FY 1999	FY 2011	Percent Growth
ORD	Chicago O'Hare International	898,855	1,120,000	24.6%
ATL	Hartsfield Atlanta International	895,435	1,249,000	39.5%
DFW	Dallas/Fort Worth International	867,146	1,130,000	30.3%
LAX	Los Angeles International	771,337	1,023,000	32.6%
DTW	Detroit Metropolitan Wayne County	561,295	801,000	42.7%
PHX	Phoenix Sky Harbor International	555,793	801,000	44.1%
LAS	McCarran International	523,424	749,000	43.1%
MIA	Miami International	523,277	673,000	28.6%
OAK	Metropolitan Oakland International	508,454	605,000	19.0%
BOS	Boston Logan International	505,483	547,000	8.2%
	Total ➤	**6,612,498**	**8,700,011**	**31.0%**

Figure 3-3

Ten Busiest Airports by 1999 Operations FY 1999 and Forecast for FY 2011

4 The 1999 ACE Plan reported forecasts for individual airports for FY 2013. The forecasts in the 2000 ACE Plan extend only to 2011 to be consistent with the time frame of the national forecast, published in *The FAA Aerospace Forecast*, March 2000.

3.2 Air Cargo Activity

Air cargo is transported in the baggage compartments of passenger aircraft and by freighters. Figure 3-4 summarizes the amount of cargo loaded and unloaded at the busiest ten cargo airports for the past three calendar years.

Figure 3-4
Ten Busiest Cargo Airports

ID	City	Airport	1997	1998	1999
MEM	Memphis, TN	Memphis International	1,934	2,369	2,412
LAX	Los Angeles, CA	Los Angeles International	1,719	1,861	1,969
JFK	New York, NY	John F. Kennedy International	1,636	1,604	1,728
ANC	Anchorage, AK	Anchorage International	1,269	1,289	1,657
ORD	Miami, FL	Miami International	1,710	1,793	1,651
MIA	Chicago, IL	Chicago O'Hare International	1,260	1,402	1,481
SDF	Louisville, KY	Louisville International	1,369	1,395	1,440
EWR	Newark, NJ	Newark International	958	1,094	1,093
IND	Indianapolis, IN	Indianapolis International	609	813	1,041
DAY	Dayton, OH	Dayton International	767	893	895

Source: Airports Council International, *Worldwide Airport Traffic Report* 10, 2000

3.3 General Aviation Activity

General aviation (GA) includes all segments of the aviation industry except commercial air carriers and the military. The vast majority of the more than 19,000 U.S. airports, some 96.5 percent, are used exclusively by GA aircraft. Most of these are small rural airports and operations there have limited interaction with the air traffic control system. Nonetheless, there were over 40 million GA operations at airports with FAA and contract air traffic control service, well over 50 percent of total aircraft operations. Figure 3-5 shows the ten busiest general aviation airports, ranked by 1999 GA operations.

Figure 3-5
Ten Busiest General Aviation Airports FY 1999 Operations

ID	City/Airport	Air Carrier	General Aviation	Other	Total Ops
VNY	Van Nuys	0	564,979	5,994	570,973
LGB	Long Beach/Daughtery	15,518	480,538	8,568	504,624
APA	Denver/Centennial	2	401,493	30,828	432,323
DAB	Daytona Beach International	5,408	368,858	1,791	376,057
SFB	Orlando/Sanford	4,017	367,481	559	372,057
SNA	Santa Ana/John Wayne	81,999	358,612	7,621	448,232
PRC	Prescott/E.A. Love Field	226	349,299	5,319	354,844
FTW	Fort Worth Meacham	211	335,908	3,037	339,156
PTK	Pontiac/Oakland County International	612	324,054	12,392	337,058
OAK	Metropolitan Oakland International	162,766	290,175	55,513	508,454

General aviation also has a significant presence at major U.S. airports. Figure 3-6 shows that GA traffic accounted for ten percent of total aircraft operations at the 31 large-hub airports. The actual percentages varied from just 1.5 percent at Seattle-Tacoma to 37.5 percent at Honolulu. At seven of the busiest U.S. airports, GA operations represented more than 15 percent of operations.

Airport	ID	Total Operations	GA Operations	GA % Total
Hartsfield Atlanta International	ATL	898,435	26,002	2.9%
Boston Logan International	BOS	505,483	35,537	7.0%
Baltimore-Washington International	BWI	306,819	35,467	11.6%
Charlotte-Douglas International	CHS	445,485	59,602	13.4%
Greater Cincinnati-Northern Kentucky Intl	CVG	466,030	30,043	6.4%%
Ronald Reagan National	DCA	315,737	60,790	19.3%
Denver International	DEN	494,884	17,003	3.4%
Dallas-Ft. Worth International	DFW	867,146	48,997	5.7%
Detroit Metropolitan Wayne County	DTW	561,295	71,689	12.8%
Newark International	EWR	463,492	19,060	4.1%
Fort Lauderdale-Hollywood International	FLL	279,823	94,100	33.6%
Honolulu International	HNL	245,002	91,803	37.5%
Washington Dulles International	IAD	459,098	64,429	14.0%
George Bush Intercontinental	IAH	460,158	25,302	5.5%
New York John F. Kennedy International	JFK	354,952	14,252	4.0%
Las Vegas McCarran International	LAS	523,424	133,815	25.6%
Los Angeles International	LAX	771,337	18,536	2.4%
New York LaGuardia International	LGA	367,520	19,469	5.3%
Orlando International	MCO	363,261	37,263	10.3%
Miami International	MIA	523,277	73,009	14.0%
Minneapolis-St. Paul International	MSP	505,064	112,670	22.3%
Chicago O'Hare International	ORD	898,855	28,880	3.2%
Philadelphia International	PHL	478,397	51,021	10.7%
Phoenix Sky Harbor International	PHX	563,843	83,791	14.9%
Greater Pittsburgh International	PIT	439,032	26,149	6.0%
San Diego International Lindbergh Field	SAN	224,095	16,847	7.5%
Seattle-Tacoma International	SEA	430,572	5,335	1.2%
San Francisco International	SFO	436,659	28,031	6.4%
Salt Lake City International	SLC	368,982	79,059	21.4%
Lambert St. Louis International	STL	503,538	23,837	4.7%
Tampa International	TPA	272,330	48,939	18.0%
Total ➤		**14,794,025**	**1,480,727**	**10.0%**

Figure 3-6

Percentage of GA Activity at Large Hub Airports FY 1999 Operations

3.4 New Sources of Demand

The FAA forecasts robust growth for all existing aviation activity. A number of aviation industry developments may have long-term impacts on the demand for aviation services. Chapter One discussed the outlook for regional jet operations, an important new source of demand that is already having an impact. This section discusses the outlook for a number of additional sources of potential future demand: Fractional Ownership, the Small Aircraft Transportation System, New Large Aircraft, and Commercial Space Transportation.

3.4.1 Fractional Ownership

Fractional ownership allows participants to purchase a share in an aircraft for their occasional use. Unlike traditional time-share programs, in which several buyers purchase a single aircraft together and must coordinate schedules, fractional owners have full access to their aircraft or a comparable one, on as little as four hours notice. Using a business aircraft (owned by an

individual or under a fractional arrangement) instead of a commercial airline allows travelers to bypass major airports and to take advantage of the thousands of general aviation airports, which are less congested and more dispersed.

Fractional ownership has grown steadily since its introduction and that growth appears to be accelerating. In 1999, the number of individual and corporate fractional shareowners grew from 1,215 to 1,693, a 39 percent increase, and the number of aircraft, primarily jets, in fractional programs grew from 253 to 370, a 46 percent increase.

Historically, most fractional ownership programs have operated under Federal Aviation Regulation (FAR) Part 91, which regulates general aviation business activities. However, some programs operate under Part 135, which regulates on-demand and scheduled air transportation and has more stringent requirements. In response to this rapid growth, the FAA has initiated a review of fractional programs to determine if they are operating within the appropriate regulatory structure.

In October 1999, the FAA created the Fractional Ownership Aviation Rulemaking Committee (FOARC), with representatives of fractional owners and managers, aircraft manufacturers, trade associations, the FAA, the Department of Transportation, foreign civil aviation authorities, and others. The FOARC met in November and December 1999 and presented its initial recommendations in February 2000. The committee's key recommendation was that the FAA create a new subpart K of Part 91 to standardize and clearly define the safety responsibilities of fractional owners and fractional ownership programs. The FOARC also suggested that comparable alternative means for compliance for certain part 135 on-demand air carriers be developed. The FAA is preparing a Notice of Proposed Rulemaking to incorporate the FOARC recommendations.

3.4.2 The Small Aircraft Transportation System

In October 1998, the FAA and NASA Administrators announced a plan to address the future of general aviation, the National General Aviation Roadmap. A key element of the GA Roadmap is the development of an intermodal, personal, rapid transit air travel system called The Small Aircraft Transportation System (SATS). Long-term SATS goals include:

- Reducing national travel times by 50 percent and providing near all weather access to 25 percent of the nation's public use airports
- Reducing the time it takes to become a pilot from seven months to three months and reducing the costs of learning to fly
- Increasing safety through advances in aircraft, avionics, and engine design

NASA and the FAA, along with various universities, manufacturers, and states are working together to develop SATS demonstration projects over the next decade. Manassas Regional Airport, Virginia's busiest general aviation airport, with 130,000 operations per year and 350 based aircraft, was designated the first SATS airport. Two other Virginia airports, Blacksburg and Newport News, were subsequently named. These airports have the required surface conditions, flight service providers, and airport equipment for a successful demonstration. Future plans include implementation of promising aviation technologies and upgrading existing Aviation Weather Operating Systems and Aviation Surface Observation Systems, weather dissemination equipment, and communications equipment. Differential GPS approaches, smaller runway protection zones, new approach procedures and an airborne internet-based self separation and queuing capability will be demonstrated by NASA and FAA at these airports.

3.4.3 New Large Aircraft

For the past several years, Boeing and Airbus have been considering developing new large aircraft (NLA) with seating capacities exceeding 400 passengers. Airbus foresees a demand for 1,300 passenger aircraft in the more than 400-seat category and 300 all-cargo derivatives over the next 20 years. Boeing's forecasts are much more conservative, predicting that carriers will need no more than 400 NLA in that period.

In June 2000, Airbus received approval from its shareholders to begin making offers to customers for a 555-seat double-deck jetliner, the A3XX. Their current timetable calls for a first flight in 2004 and entry into service in the last quarter of 2005. Boeing has tentative plans to develop a family of stretched versions of the 747, referred to as the 747X family, which will include a passenger, freighter, and long-distance airplane. The 747X passenger model would be capable of carrying more than 500 passengers.

Thirty years ago, when Boeing first introduced the 747, the FAA upgraded its standards and guidance material to accommodate that larger-than-typical aircraft. Today, with both Airbus and Boeing proposing introduction of a NLA, airport design standards are under scrutiny again. A substantial number of existing U.S. large-hub airports were designed to meet the requirements of the 747. These airports, with maximum 75-foot wide taxiways and separations and clearances that reflect operational requirements for aircraft with wingspans less than 65 meters, are referred to as design group V airports. Only a few U.S. airports have been built to or have had a portion of their airfield built to design group VI standards, capable of handling aircraft with wingspans of up to 80 meters. Accommodating NLA at design group V airports would require operational modifications, such as restricting traffic on adjacent runways or taxiways.

Airports that are now served by Boeing's 747 are the most likely candidates for NLA service. In 1998, the Airports Council International (ACI) surveyed airports about the construction costs of bringing an NLA into service. Los Angeles and Kennedy airports, which now have the most 747 passenger flights, estimated that it would cost more than $100 million to make the runway and taxiway modifications required to accommodate an NLA, using current design group VI standards. Terminal and apron modifications would push the costs even higher.

The FAA's NLA Facilitation Group, composed of representatives from Airbus, Boeing, ACI, a variety of FAA organizations, and a number of airports, is working to develop criteria under which a design group VI aircraft could operate at airports that have been built to design group V standards. A key strategy is to design a risk-based approach to determining safe airport clearances to replace the current wingspan-based formula.

The FAA is also reviewing its standards for wake vortex separation, which now rely on a weight-based formula. The FAA has proposed that manufacturers conduct the required studies to describe the wake vortex characteristics of an NLA. The results of those studies will aid the FAA in determining appropriate in-trail separation. Finally, the FAA is conducting taxiway deviation studies to assess the risk of an NLA running off a taxiway and whether obstacle free zones at design group V airports can safely handle an NLA in the case of a balked landing.

3.4.4 Commercial Space Transportation

The FAA's Associate Administrator for Commercial Space Transportation (AST) regulates the U.S. commercial space transportation industry, licenses commercial launches and launch sites, and manages the airspace required for commercial launches to ensure safety. Most

commercial space launches contain communications, scientific, weather, or remote-sensing satellites and are financed by private corporations, states, the Air Force, and NASA. The majority of commercial space launches occur from federal spaceports where the Department of the Defense owns the infrastructure. Unlike airports, where the FAA builds and maintains air traffic control facilities, the FAA has no infrastructure at spaceports.

There are four FAA-licensed spaceports in the U.S.: Spaceport Florida, California Spaceport, Virginia Space Flight Center, and Kodiak Launch Complex (Alaska). Boeing Sea Launch, a sea-based floating platform financed by a Boeing-led international consortium, also operates under the authority of an FAA-issued launch license. Other possible sites for commercial launches include locations in New Mexico, Texas, Nevada, Utah, and Montana.

Since 1989, when the first commercial launch took place, 131 FAA-licensed launches have taken place. Market forecasts indicate that approximately 1,200 launches will occur worldwide over the next decade, with a majority of the launches being conducted in the United States by U.S. launch vehicle operators.

Commercial space launches so far have had little impact on NAS operations because of their infrequency of occurrence and because most launches have been conducted within restricted military airspace. However, as the number and types of launches increase, the FAA will be challenged to mitigate their impact on existing air traffic. Space vehicles are now launched vertically, but commercial space vehicles under development, including certain reusable launch vehicles (RLV), will depart horizontally, passing through the NAS to an airborne launch point where their vertical ascent is initiated. RLVs making horizontal departures may take off and re-enter under power using conventional runways, potentially at great speeds. New airspace structures will be required to provide dynamically reserved and released airspace to allow space vehicles to pass through the NAS.

CAPACITY OF THE NATIONAL AIRSPACE SYSTEM

4

4 CAPACITY OF THE NATIONAL AIRSPACE SYSTEM

The two basic elements of the NAS, its airports and its airspace, are equally important in determining the capacity of the system. At any given time, that capacity is determined by conditions at the airports and their management by local operators, and by the status of the airspace and its management by the FAA. Only through the coordinated management of both elements can the air transportation system function effectively.

When either NAS element is adversely affected, system capacity is reduced. When conditions prevail that reduce the capacity of a large airport (bad weather, winds that necessitate the use of a less than optimal runway configuration, runway closure, and so forth), the effects ripple through the surrounding terminal airspace and, if those conditions persist, through en route airspace as well. These problems in the airspace can ultimately impact operations at other airports. Similarly, if bad weather in an en route sector reduces airspace capacity and restrictions are placed on traffic entering or transiting that airspace, the effects will soon reach nearby airports.

4.1 Airspace Capacity

Airspace capacity is the theoretical maximum number of aircraft that physically can be in a volume of airspace at a specific point in time. Actual airspace capacity is very difficult to measure because it is the result of the interaction of a number of interdependent factors that are constantly changing. Thus, capacity will be different from one moment to the next.

In operation, airspace capacity is the ability of the air traffic control system to safely manage the flow of aircraft from departure to destination at the times sought by the aircraft operators. The safe use of that airspace capacity is made possible by a complex network of communications, navigation, surveillance, and automation systems. This network is run by the FAA's air traffic services organization, including controllers, traffic management specialists, and a staff of support technicians. The efficiency of the use of airspace is contingent upon the procedures implemented by air traffic control for the safe conduct of operations through the airspace. These procedures vary by operational domain: oceanic, en route, and terminal airspace are structured differently.

In the oceanic domain, the lack of direct radar surveillance imposes a constraint on the capacity of the airspace. Safe separation requirements are significantly greater here because air traffic controllers rely on infrequent radio communications to monitor aircraft position. Separation in oceanic airspace is 100 nautical miles horizontally and 2,000 feet vertically. In the en route domain, where there is direct radar surveillance, separation varies by altitude. Traffic below FL290 must be separated from other aircraft by five miles and 1,000 feet. Traffic at FL290 or above must be separated by five miles and 2,000 feet. Aircraft flying in en route airspace follow jet routes or other flight paths that have been specified in a flight plan that has been filed with the FAA.

Traffic in terminal airspace, where aircraft fly more slowly, must be separated from other aircraft by three miles and 1,000 feet.[5] Aircraft flying in terminal airspace follow standard instrument departures (SIDs) and standard terminal arrival routes (STARs), or the directions of an air traffic controller.

5 On approaches and departures, longitudinal separation standards are increased when different types of aircraft are following one another in order to limit the impact of wake vortices. For example, if the leading aircraft is a so-called heavy, such as a B-747, another heavy aircraft must maintain four miles longitudinal separation, a large aircraft must maintain five miles, and a small aircraft must maintain five or six miles.

4.1.1 Factors Affecting Airspace Capacity

Airspace capacity is theoretically infinite, in that the cubic volume of airspace is sufficient to allow all existing aircraft to be airborne simultaneously and not be in conflict with one another. In reality however, the nation's air traffic is not evenly distributed throughout the day or among all airports. Operations tend to be concentrated in the airspace near the major airports and along defined routes, particularly during the most convenient travel times. At these periods of peak operations, demand may exceed the airspace capacity in these locations. When this occurs, air traffic control flow management and traffic separation standards ensure that actual operations do not exceed the airspace capacity. The trade-off for such safety assurance measures is that some aircraft are delayed.

Similarly, hazardous weather phenomena such as thunderstorms or icing conditions can reduce airspace capacity or close the airspace entirely, necessitating changes in traffic flows and air traffic control separation requirements. Poor weather conditions dictate the re-routing of aircraft, thereby delaying some planes and increasing demand on other airspace. If the hazardous weather is prolonged, airspace capacity limitations may have a ripple effect, causing ground holds, delayed arrivals, and flight cancellations.

Airspace capacity is also limited by the use of special use airspace. Most special use airspace is reserved for various military training and operational needs, effectively withdrawing that volume of airspace from use by air traffic, and reducing system capacity.

4.2 Airport Capacity

An airport is divided into airfield and landside sections. The airfield is comprised of runways, taxiways, apron areas, aircraft parking positions, air traffic control facilities, and navigational aids. The landside consists of the terminal building and the associated access roads. Although landside capacity is an important aspect of the air transportation system, it is entirely managed by the airport operators and is therefore beyond the scope of this document. Consequently, the use of the term airport capacity in this chapter refers to airfield capacity.

The number and placement of runways and taxiways, the types of navigation aids, and the types of air traffic control equipment and facilities determine airport capacity. But other variables such as aircraft performance, the mix of aircraft types, pilot proficiency, weather, and runway closures affect how much of an airport's capacity can be used at a given time. The capacity in use is often less than the capacity that would be available if there were no such limitations.

An airport's capacity is highest under visual flight rules (VFR) weather conditions. All the runways can be used for landing, including those for which no instrument approach is available, as well as intersecting runways. In addition, pilots can assume responsibility for aircraft spacing, delay configuring the aircraft for landing until it is closer to the runway, and need not fly instrument approach procedures.

The capacity of an airport is actually a range of values. Each value is associated with a specific runway configuration, airport operating conditions (including ceiling and visibility), the mix of aircraft types using the airport and the proportions of arrivals and departures. Figure 4-1 shows the actual hourly departure and arrival rates at the large-hub airports during CY 1999.[6]

6 Total operations are less than the sum of hourly arrivals and departure rates because some runway configurations allow more arrivals and others allow more departures, while total operations reflect the number of arrivals and departures that can be handled simultaneously.

Figure 4-1

Hourly Arrival and Departure Rates at Large Hub Airports, CY 1999

Airport	ID	Departures	Arrivals	Total Operations
Hartsfield Atlanta International	ATL	99	98	190
Boston Logan International	BOS	58	55	106
Baltimore Washington International	BWI	35	36	61
Charlotte-Douglas International	CLT	58	53	102
Greater Cincinnati/Northern Kentucky Intl	CVG	75	62	124
Ronald Reagan National	DCA	39	39	71
Denver International	DEN	64	63	113
Dallas/Fort Worth International	DFW	104	111	212
Detroit Metropolitan Wayne County	DTW	72	69	131
Newark International	EWR	54	51	93
Fort Lauderdale International	FLL	31	30	54
Washington Dulles International	IAD	70	71	112
George Bush Intercontinental/Houston	IAH	59	62	112
New York John F. Kennedy International	JFK	50	56	82
Las Vegas McCarran International	LAS	42	42	76
Los Angeles International	LAX	81	83	145
New York LaGuardia	LGA	42	42	79
Orlando International	MCO	40	43	73
Miami International	MIA	60	60	106
Minneapolis-St. Paul International	MSP	66	68	118
Chicago O'Hare International	ORD	100	99	183
Philadelphia International	PHL	57	60	103
Phoenix Sky Harbor International	PHX	56	57	104
Greater Pittsburgh International	PIT	70	68	105
San Diego International Lindbergh Field	SAN	27	26	46
Seattle-Tacoma International	SEA	51	48	83
San Francisco International	SFO	50	50	90
Salt Lake City International	SLC	42	47	77
Lambert-St. Louis International	STL	61	62	111
Tampa International	TPA	33	33	57

Total operations in this figure are less than the sum hourly arrival and departure rates. The differences results from implementation of various runway usage configurations, some which allow more arrival, others which allow more departures, while total operations reflect the number of arrivals and departures that can be handled simultaneously.

For the large-hub airports, ETMS is 89.4% of official traffic counts. The major reason for this difference is that ETMS does not capture any general aviation VFR traffic. Therefore, these percentile values may slightly understate actual rates.

Arrival and departure rates from 0700 to 2159 local time.

Source: Enhanced Traffic Management System; excludes Honolulu (HNL).

4.2.1 Factors Affecting Airport Capacity

The primary determinant of an airfield's capacity is its physical design: the number, length, and location of runways, intersections, taxiways, gates, and the distance between parallel runways. Nonetheless, capacity varies greatly within the absolute limitations of an airport's physical design, and this variability of capacity is an important factor in airport operations and aircraft scheduling. A variety of considerations affect an airport's most efficient runway configuration. These considerations can be grouped into five categories: Airfield Resources, Visibility and Meteorological Conditions, Air Traffic Control Procedures, Noise Considerations, and Aircraft Demand.

4.2.1.1 Airfield Resources

The number, length, and orientation of an airport's runways and taxiways determine the operational practices that can be used under different weather or demand conditions. The lighting and navigational aids available at an airport, such as one or more Instrument Landing Systems (ILS), determine whether particular runways can be used when visibility is poor. A distance of more than 4,300 feet between parallel runways allows parallel independent ILS approaches to be flown, helping to increase capacity. In some cases, obstructions in the approaches, runway length or weight bearing limitations, and poor pavement condition increase runway occupancy times, lower airfield capacity, and may limit the types of aircraft permitted to use a runway. Events such as runway closures or outages of navigational aids can temporarily reduce capacity.

4.2.1.2 Visibility and Meteorological Conditions

Changes in wind, weather, and visibility are the most important causes of variations in capacity. Particular wind directions can mandate the use of lower capacity runway configurations. Low ceilings, precipitation, and accumulations of snow and ice on the runway can severely restrict aircraft operations or close the airport altogether. The extent to which changes in weather and visibility affect capacity depend to a significant degree on airfield resources, i.e., the type of navigational and landing systems available and the separation of the runways.

Air carrier schedules are based on optimal conditions and the associated airport capacity. If the visibility is at least three statute miles and cloud heights are at least 1,000 feet (VFR conditions), pilots can use visual approaches to the airport. When the visibility is below the minimum required for visual approaches, pilots must fly instrument-aided approaches, operations must be conducted under Instrument Flight Rules (IFR), aircraft must be spaced farther apart, and must fly longer, well-defined approach paths.

Other weather conditions can have dramatic effects on aircraft operations. Thunderstorms can greatly reduce or stop arrivals to an airport, since aircraft cannot safely fly near or through thunderstorms. Snow or ice on the runway surface can also increase the arrival spacing between aircraft because of the reduced effectiveness of aircraft brakes, resulting in longer landing rolls and increased runway occupancy times.

4.2.1.3 Air Traffic Control Procedures

Air traffic control procedures, which ensure safe separation between aircraft leaving and entering the terminal area, provide greater separation under IFR conditions than are commonly maintained under VFR conditions. Rules regarding the use of converging and parallel runways during instrument operations reduce the use of runways, often limiting an airport to single runway operation when visibility is poor.

4.2.1.4 Noise Abatement Procedures

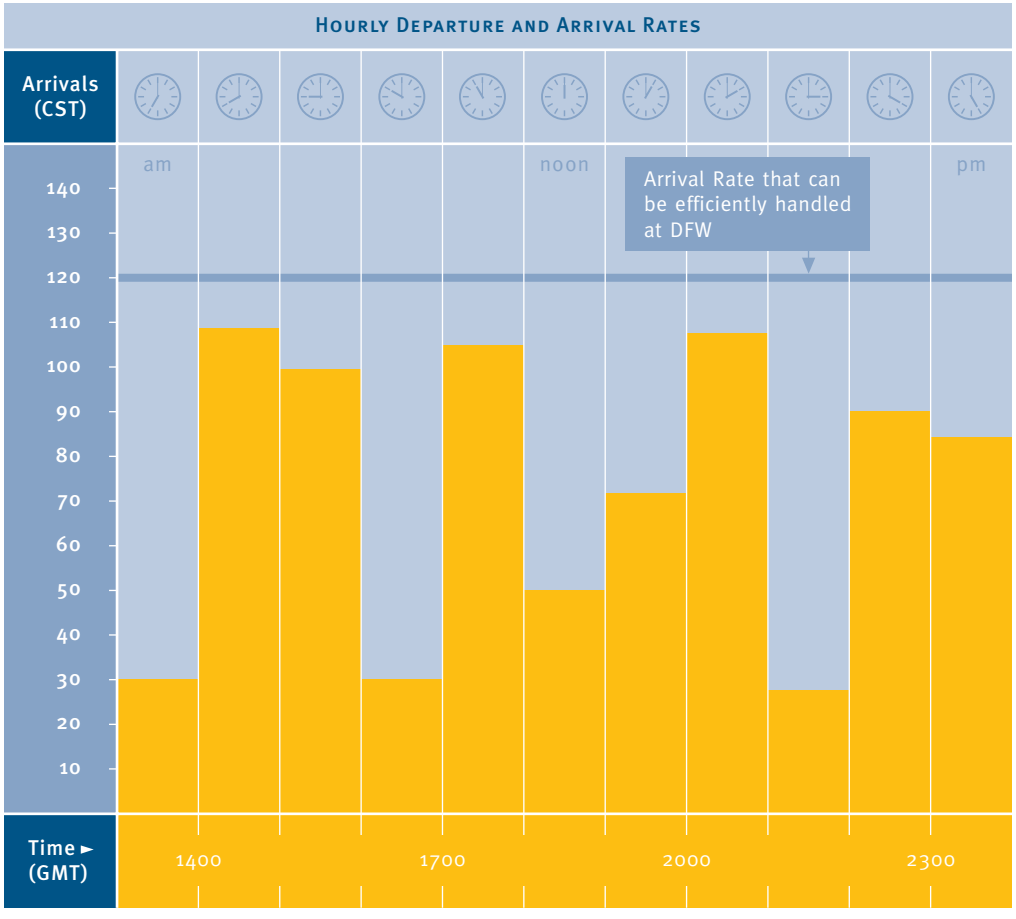
Noise abatement procedures established for an airport can reduce available capacity during certain hours of the day. These procedures generally restrict the use of departure and approach paths that pass over residential areas or limit airport operations at certain times of day. Such restrictions may limit the use of runway configurations with the highest capacity.

4.2.1.5 Demand

The pattern of aircraft demand, which refers to the number of aircraft seeking access, as well as their size, weight, performance characteristics, and desired access time, is an important determinant of capacity. The performance characteristics of aircraft affect the rate at which operations can be maintained. For example, to protect smaller planes from wake vortex turbulence, in-trail arrival separation between small and large aircraft must be greater than that required between two large aircraft. The runway occupancy times of different types of aircraft also affect separation requirements and thus capacity. As demand approaches airport capacity, congestion and minor delays begin to occur.

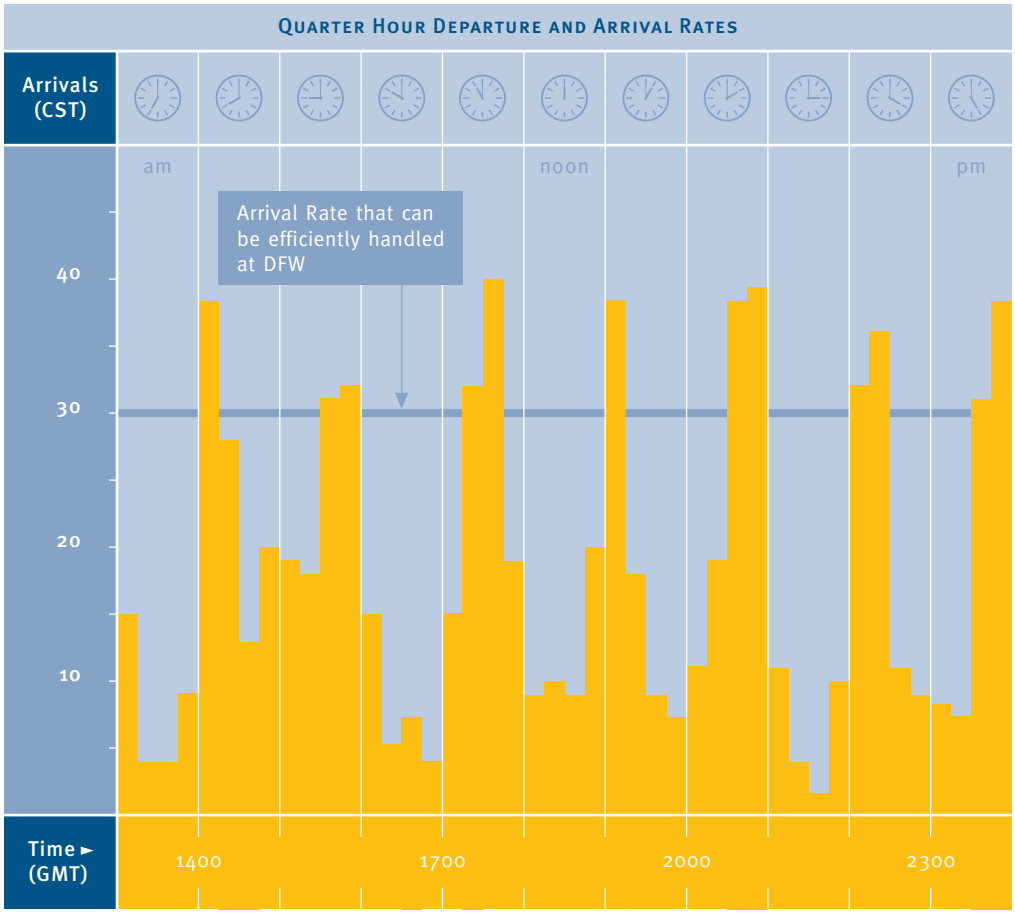
Airport capacity is expressed as the maximum number of operations (takeoffs and landings) that can occur within a given period of time using standard air traffic management practices. This expression of airport capacity assumes that the demand for service is continuous (i.e., that there are always aircraft ready to takeoff or land). NAS capacity would be closer to the maximum if traffic were evenly distributed throughout the day (and night) and among all airports. In practice, however, traffic demand surges and ebbs. This variability is most pronounced at the large hub-and-spoke airports, where a series of banks of flights results in pronounced peaks and troughs in demand. Figure 4-2 shows such a pattern in the daily arrival demand at Dallas/Fort Worth International Airport (DFW), which varies from a high of about 110 flights per hour to a low of 30 flights per hour.

Figure 4-2
Variability in Demand at DFW (Hourly)



Source: Federal Aviation Administration, Airport Arrival Demand Chart for DFW, October 31, 2000.

The traffic bank's characteristic peaks in demand and the troughs that follow are more apparent if the daily arrival demand at DFW is plotted in 15-minute intervals. Figure 4-3 shows a very large variation in demand, with one period of 40 flights per quarter hour and a number of periods following or preceding the peaks where the demand is less than ten flights per quarter hour.



Source: Federal Aviation Administration, Airport Arrival Demand Chart for DFW, October 31, 2000.

Figure 4-3
Variability in Demand at DFW (Quarter Hour)

Figures 4-2 and 4-3 also illustrate the impact of the variability of demand on airport capacity. In both figures, DFW's hourly capacity is indicated by a horizontal blue line. In Figure 4-2, the hourly capacity of 120 flights is never exceeded, while in Figure 4-3, the airport's capacity of 30 flights per quarter hour (simply 120 divided by four) is exceeded in 12 periods, and from 1730 to 1745 hours the demand exceeds capacity by one third.

4.2.1.6 Airport Congestion

Variability in capacity, combined with the pattern of demand, can cause airport congestion, typically, the formation of aircraft queues awaiting permission to arrive or depart. If demand, on average, is lower than capacity, then occasional surges in demand may be followed by periods of relative idleness during which queues can be dissipated. But when demand approaches or exceeds capacity for extended periods, it becomes increasingly difficult to eliminate backlogs. Any unexpected increase in demand or disruption that reduces capacity, even if it is relatively short-lived, can result in rising levels of delay that may persist throughout the day.

IMPROVING SYSTEM PERFORMANCE

5

5 IMPROVING SYSTEM PERFORMANCE

Delay is the traditional measure of NAS performance, but the FAA is beginning to broaden its perspective to take into account the interactions among capacity, demand, and delay, and other aspects of system performance such as flexibility and access to airports, airspace, and aviation services. This chapter presents system performance data related to delay and the demand/delay trade-off, describes significant new FAA initiatives for enhancing system performance in the near-term, and summarizes Department of Transportation intermodal strategies.

5.1 Demand, Capacity, and Delay

During a given hour, if aircraft using an airport sought service at a continuous rate equal to that at which aircraft operations could be processed, and if operating conditions at the airport were constant throughout the hour, then operations could reach the airport's highest capacity without significant delays. However, the rate at which aircraft arrive and depart is never continuous. There are periods during an hour when several aircraft demand service at the same time and periods when none arrive or depart. Therefore, the number of operations an airport actually processes usually is less than the airport's highest capacity, even when the weather is favorable.

As demand approaches airport capacity, some delays related to congestion will occur. However, if demand begins to exceed airport capacity, delays will become more significant and occur at an increasing rate. The FAA models the relationship between capacity, increasing demand, and delay in its Airport Capacity Enhancement Design Team studies. The FAA's NAS Advanced Concepts Branch recently used the same methodology to calculate Annual Service Volumes (ASV) for the top 25 airports, two examples of which are presented here. By performing a series of simulations with increasing demands, they developed a series of demand/delay curves that show average delay per operation as a function of the number of annual operations, from which ASVs can be determined.

Figure 5-1 presents Annual Service Volume estimates and demand/delay curves for Salt Lake City International Airport (SLC). The figure shows that average delays at SLC are modest until annual operations exceed 450,000. Without capacity improvements, the average delay per operation increases rapidly as annual operations exceed 500,000. There is a trade-off between demand and delay, with increases in demand being accommodated only at the cost of increased delay.

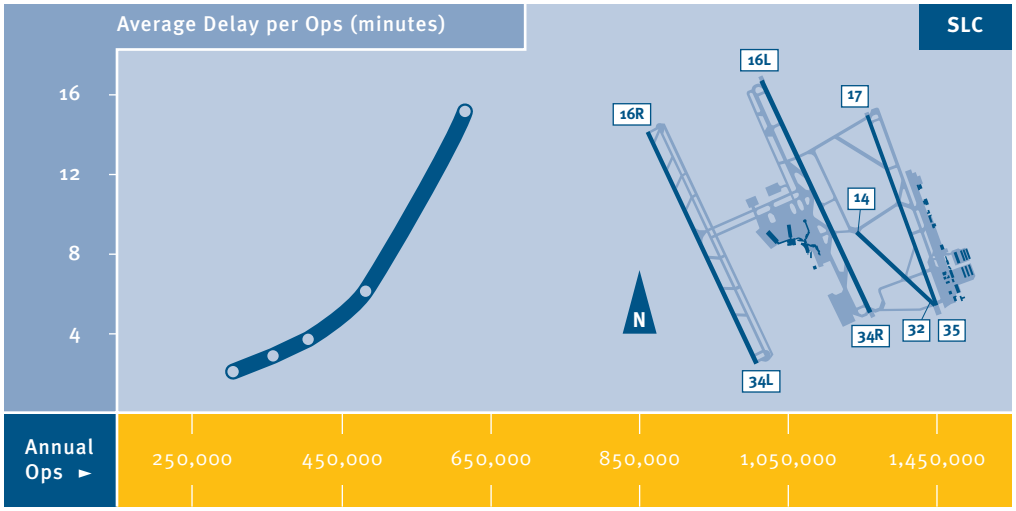


Figure 5-1
Annual Service Volume Estimates: Annual Demand and Delay at Salt Lake City International Airport

An airport can meet increased demand without incurring large delays by increasing its capacity. Since the most effective way to increase capacity is to build additional runways, the FAA developed demand/delay curves for selected airports assuming the construction of new runways. Figure 5-2 illustrates the impact of the construction of a new runway at Orlando International Airport (MCO): the demand/delay curve moves significantly to the right. The shift indicates that a new runway would allow more operations to be accommodated with fewer delays. With the present runway infrastructure, delays at MCO are estimated to begin to increase rapidly when operations exceed 600,000 annual operations. With a new runway, the airport would be able to accommodate that level of operations without difficulty and delays are not projected to reach a significant level until operations approach 850,000 per year.

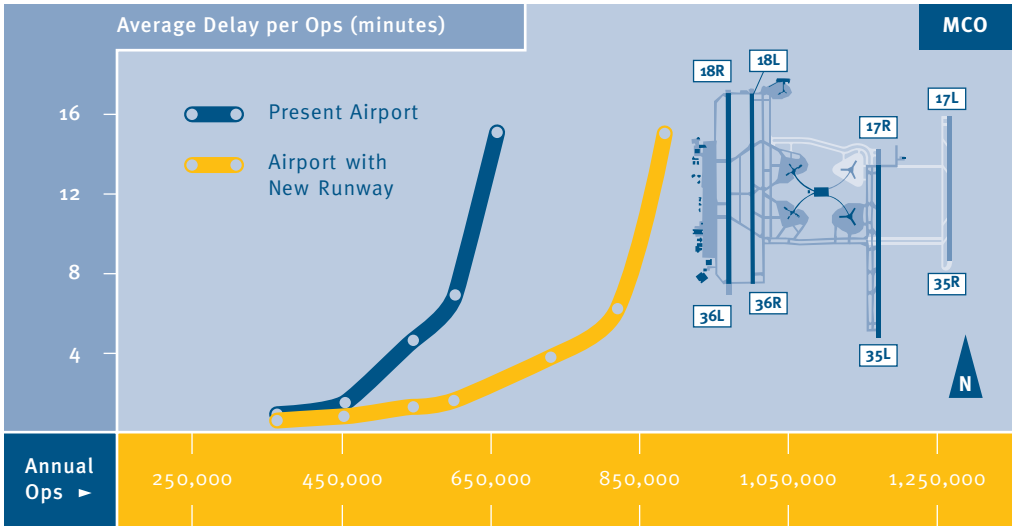


Figure 5-2
Annual Service Volume Estimates: Impact of a New Runway at Orlando International Airport

5.2 Delays in the National Airspace System

The FAA uses two different systems to track delays, the Operations Network (OPSNET) and the Consolidated Operations and Delay Analysis System (CODAS). OPSNET data come from observations by FAA personnel, who manually record aircraft that are delayed by 15 minutes or more during any phase of flight. Aircraft that are delayed by less than 15 minutes in any phase of flight are not recorded. OPSNET also provides information on the cause of delay: weather, volume, closed runways/taxiways, NAS equipment interruptions, and other. OPSNET reports delays for specific airports, but does not report delay by carrier or by flight.

According to OPSNET data, 374,116 flights were delayed 15 or more minutes in 1999, an increase of 22 percent over the 306,234 flights delayed in 1998. Figure 5-3 shows the trends in the distribution by cause of flights delayed 15 minutes or more for the last four years and the first nine months of 2000. The primary causes of delay vary little year over year, with a large majority of delays attributed to weather and a smaller but significant percentage to volume.

Figure 5-3
Annual Delays by Cause

Cause	1996	1997	1998	1999	Jan-Sept 2000(p)
Weather	200,930	166,783	227,764	257,261	254,193
	74.0%	68.0%	74.4%	68.8%	70.9%
Volume	50,108	54,415	44,932	44,317	43,670
	18.5%	22.2%	14.7%	11.8%	12.2%
NAS Equipment	5,873	6,394	5,962	7,709	5,626
	2.2%	2.6%	1.9%	2.1%	1.6%
Runway	5,947	8,073	8,268	17,422	20,986
	2.9%	3.3%	2.7%	4.6%	5.8%
Other	6,649	9,594	19,308	47,407	33,905
	2.4%	3.9%	6.3%	12.7%	9.5%
Total Delays ➤	**271,507**	**245,259**	**306,234**	**374,116**	**343,124(p)**

(p): preliminary numbers

Although an annual summary provides a useful guide to the trends in delays over time, the number of delays also varies substantially by month. Figure 5-4 shows the number of delays by month for the last four years and for the first nine months of 2000. The greatest number of delays generally occur during the summer months, when afternoon thunderstorms are prevalent.

Figure 5-4
Delays by Month

	1996	1997	1998	1999	Jan-Sept 2000(p)
January	25,082	21,588	27,623	24,345	26,015
February	18,955	15,856	24,855	19,851	27,208
March	18,598	15,055	24,159	23,180	32,205
April	19,303	17,453	22,563	34,046	35,332
May	22,200	19,177	29,187	39,533	36,570
June	29,776	25,068	37,093	41,602	50,114
July	25,544	26,193	25,672	45,162	44,430
August	24,203	24,816	30,549	37,189	47,893
September	25,422	19,388	20,194	32,833	43,357(p)
October	21,452	17,812	23,988	28,223	N/A
November	17,294	22,337	20,439	23,330	N/A
December	23,678	20,516	19,912	24,822	N/A
Total Delays ➤	**271,507**	**245,259**	**306,234**	**374,116**	**343,124(p)**

(p): preliminary numbers

CODAS provides information on delay by phase of flight by tracking all aircraft movements that exceed scheduled or unimpeded times. CODAS receives actual times for gate out, wheels off, wheels on, and gate in. From this information, supplemented by data from other databases, CODAS calculates the actual delays that a flight experiences as it moves through the NAS. Figure 5-5 ranks the large-hub airports by average delay for each phase of flight and by operation (arrivals plus departures). In general, taxi-out delays are longer than airborne or taxi-in delays. LaGuardia and Newark airports have the largest taxi-out delays of the large-hub airports as well as the largest delays per operation.

Figure 5-5
Delays by Phase of Flight

Taxi Out Delay		Airborne Delay		Taxi In Delay		All Phases	
Airport	Min/Dep	Airport	Min/Arr	Airport	Min/Arr	Airport	Min/Op
LGA	13.2	EWR	6.4	DTW	3.4	EWR	11.3
EWR	13.0	ATL	6.2	DFW	3.3	LGA	10.4
PHL	8.3	PHL	5.5	LAX	2.8	ATL	8.7
ATL	8.2	LGA	4.8	EWR	2.6	PHL	8.5
DTW	7.7	IAD	4.7	ATL	2.4	DTW	7.4
JFK	7.6	MSP	4.4	ORD	2.4	MSP	7.0
MSP	7.1	SEA	4.3	STL	2.2	ORD	7.0
ORD	7.0	BOS	4.3	BOS	2.1	BOS	7.0
STL	6.9	ORD	4.1	MSP	2.1	JFK	7.0
BOS	6.5	JFK	3.8	PHL	2.0	STL	6.5
DFW	6.0	SLC	3.8	LGA	2.0	DFW	6.2
CVG	5.9	CVG	3.8	MIA	1.9	IAD	6.1
IAH	5.5	SFO	3.4	PHX	1.9	LAX	5.8
IAD	5.4	CLT	3.3	JFK	1.8	CVG	5.6
PHX	5.2	STL	3.2	IAH	1.6	IAH	5.5
SFO	5.1	DTW	3.2	LAS	1.5	PHX	5.3
DCA	4.9	IAH	3.1	DEN	1.4	MIA	5.2
LAX	4.9	PIT	3.1	SFO	1.3	SFO	5.2
MIA	4.6	MIA	3.0	SLC	1.0	SEA	4.7
PIT	4.3	LAX	2.9	SEA	1.0	SLC	4.7
LAS	4.1	FLL	2.7	CLT	0.9	DCA	4.5
CLT	3.8	DFW	2.7	IAD	0.9	PIT	4.4
SLC	3.8	DEN	2.5	PIT	0.9	CLT	4.4
DEN	3.6	PHX	2.5	DCA	0.9	FLL	4.2
FLL	3.5	DCA	2.3	FLL	0.9	DEN	4.1
SEA	3.4	MCO	2.3	MCO	0.8	LAS	4.0
MCO	3.1	TPA	2.1	BWI	0.8	MCO	3.6
BWI	2.8	BWI	1.9	CVG	0.7	BWI	3.2
SAN	2.6	SAN	1.3	TPA	0.6	SAN	3.0
TPA	2.2	LAS	1.3	SAN	0.5	TPA	2.9

Excludes HNL

Taxi-Out Delay: Actual Taxi-Out Time Minus Unimpeded Taxi-Out Time

Airborne Delay: Actual Airborne Time Minus Carrier Submitted Flight Plan Time

Taxi-In Delay: Actual Taxi-In Time Minus Unimpeded Taxi-In Time

All Phases: Delay Per Operation that is Attributed to Weather and ATC

5.3 Strategies to Improve System Performance

The FAA has recently undertaken several significant initiatives to improve system performance in the near-term by working closely with NAS users and taking maximum advantage of the airspace, facilities, and equipment that are currently available. In addition, Department of Transportation initiatives to increase the performance of the overall transportation system, by capitalizing on the synergistic benefits of intermodal transportation, will enhance the performance of the aviation system.

5.3.1 The Spring/Summer Plan

In the fall of 1999, the FAA and representatives of the airline industry met to discuss the severe delays experienced during the summer of 1999. In response, the FAA proposed a series of initiatives to lessen the delays, some of which were implemented at that time. In April 2000, the President announced an initiative called the Spring/Summer Plan that proposed additional remedies. The Spring/Summer Plan is a joint FAA/industry plan designed to mitigate the effects of severe weather on the NAS through a re-commitment to collaborative decision making between the FAA and the airlines and other NAS users. Although primarily intended as a means of maintaining system predictability and capacity in times of severe weather, the improved planning, communication, and information dissemination processes that form the backbone of the Spring/Summer Plan should provide system efficiencies at other times as well. Key elements of the Spring/Summer Plan are described below.

Strategic Planning

A strategic planning team at the Air Traffic Control System Command Center (ATCSCC) conducts a conference call every two hours, from 7 a.m. to 9 p.m., with airline and air traffic control representatives. During the call, the participants generate two- and six-hour system plans, taking into consideration potential problems caused by adverse weather or high traffic volume. The resulting strategic plan is posted on the ATCSCC web site.

Route Coordination

The FAA and the airlines worked together to develop routing alternatives to facilitate efficient re-routing of traffic during severe weather. Coded departure routes (CDR) help mitigate delays by balancing traffic at available departure fixes within 200 nautical miles of the affected airport. The national playbook provides route alternatives to address the most common severe weather scenarios facing en route and arrival traffic. For example, 114 possible routes from Boston Logan International airport to 38 destination airports in the U.S. have been developed. The availability of a variety of pre-determined alternate routes provides flexibility in dealing with most severe weather events and expedites the route coordination process. It also allows airlines to plan ahead for possible route changes when severe weather is forecast. The coded departure routes and the national playbook are available on the ATCSCC web site.

Collaborative Convective Forecast Product

In the past, effective collaboration and planning of NAS operations during severe weather has been limited by conflicting convective weather forecasts. In response, the FAA has developed the Collaborative Convective Forecast Product (CCFP), a system for developing and distributing a single convective forecast four times a day. This forecast is based on input from the National Weather Service's Aviation Weather Center (AWC), the ARTCCs' Center Weather Service Units (CWSU), and airline meteorologists. The forecast covers the continental U.S., its coastal waters, and portions of Canadian airspace that are commonly used by U.S. aircraft during severe weather. Collaborative forecasts for the New York, Washington, Chicago, and Dallas areas are given top priority.

The Aviation Weather Center produces the original forecast, which is then reviewed with CWSU and airline meteorologists on an internet chat room. The AWC revises the original forecast to produce a final collaborative forecast, which is then displayed on the internet. The collaborative forecast is used by both the FAA and airline dispatchers to determine when and where to re-route traffic, cancel flights, or implement air traffic restrictions such as ground delay programs.

Improved Access to East Coast Military Airspace

The FAA and U.S. Navy have signed a letter of agreement regarding civilian use of offshore warning area airspace from Northern Florida to Maine during severe weather events. The letter specifies coordination procedures so that civilian flights can be routed through the warning area to avoid severe weather if it is not being used by the military at that time. To facilitate use of this airspace, the FAA has established waypoints along several routes for conducting point-to-point navigation when the DoD has released that airspace to the FAA. The waypoints take advantage of aircraft RNAV capabilities and provide a better demarcation of airspace boundaries, enabling a more flexible release of airspace in response to changing weather.

Improved Flight Planning Procedures

The lack of complete and accurate flight information reduces the effectiveness of traffic management decisions, thus limiting NAS efficiency and capacity. Before a flight plan is filed, traffic managers base their projections on traffic patterns from the previous 15 days. To improve the information available for planning purposes, the FAA has requested that users file their IFR flight plans at least four hours prior to departure. In addition, the FAA has requested that users who want to amend their flight plan within 45 minutes of departure call in the change to the appropriate facility instead of filing the amendment electronically, to ensure that the new flight plan information is available to air traffic controllers.

Low Altitude Alternate Departure Route

A relatively new procedure, the Low Altitude Alternate Departure Route (LAADR), is helping to relieve congestion in high altitude sectors and avoid departure delays. Under LAADR, pilots request lower-than-normal altitudes of 18,000 to 23,000 feet instead of the higher, busier altitudes. The ATCSCC makes the LAADR procedure available to pilots when a large volume of departure and high-altitude traffic is expected. When the LAADR procedure is in effect, pilots have the option of filing for high altitudes and accepting a departure delay, or requesting a lower initial altitude and being able to enter the high-altitude traffic stream when space is available.

The LAADR procedure has been used primarily with departures, but it can be extended for the entire flight. Flying at lower altitudes typically adds several minutes to the flight time and increases fuel consumption, but these costs may be outweighed by the opportunity to depart on time and to fly through less congested airspace. First implemented in New York area, LAADR is now available over the eastern half of the United States. Airlines that are using the procedure report that it helps keep traffic moving.

Diversion Recovery

During severe weather, flights are frequently diverted to alternate airports to avoid unsafe flying or landing conditions. The goal of diversion recovery is to ensure that flights that have already been penalized by having to divert to another airport do not receive additional penalties or delays. Diversion recovery is coordinated by the ATCSCC and system users. Airlines identify a diverted flight in the remarks section of its flight plan and the ATCSCC posts a list of diverted flights on its web site. Airlines review the list, add missing flights, annotate their flight priorities, and then fax the list to the ATCSCC. The ATCSCC forwards the prioritized list of flights to the appropriate ARTCCs, which in turn forward the list to the appropriate TRACONs and towers. All air traffic facilities provide priority handling to those flights identified on the distributed list or by the use of "DVRSN" in the flight plan.

User Hotline

During periods of rapidly changing conditions, the FAA activates a user hotline to provide timely operational information to the user community. Users can call the hotline to raise flight-specific or event-specific issues with an ATCSCC customer advocate.

Post Event Analysis

A team of FAA and aviation industry representatives meet twice per month to review NAS performance, with the intent of developing ideas for improving existing procedures and to develop a more efficient airspace system. Background data to support the system performance analysis is collected from the ATCSCC, air traffic facilities, and the airlines.

5.3.2. The National Choke Points Initiative

The National Choke Points Initiative was conceived at a May 2000 meeting of NAS users, FAA managers, and NATCA representatives to discuss the National Airspace Redesign. The National Airspace Redesign is a multi-year effort to increase the efficiency of the NAS through the re-routing of air traffic, the reconfiguration of the nation's airspace, and more efficient air traffic management. Meeting participants suggested that the FAA concentrate on short-term actions to improve air traffic flow at a number of system choke points. The group identified seven problem areas in the area east of the Mississippi, as far north as Boston and as far south as Atlanta. This area includes airspace in the New England, Eastern, Great Lakes, and Southern regions, as well as many of the country's major population areas and most congested airports.

Figure 5-6, which identifies the seven national choke points, shows that the choke points are not actually discrete sites, but rather airways or sections of airspace. The figure also shows the extent to which the choke points overlap, so that congestion at one can easily create congestion at another.

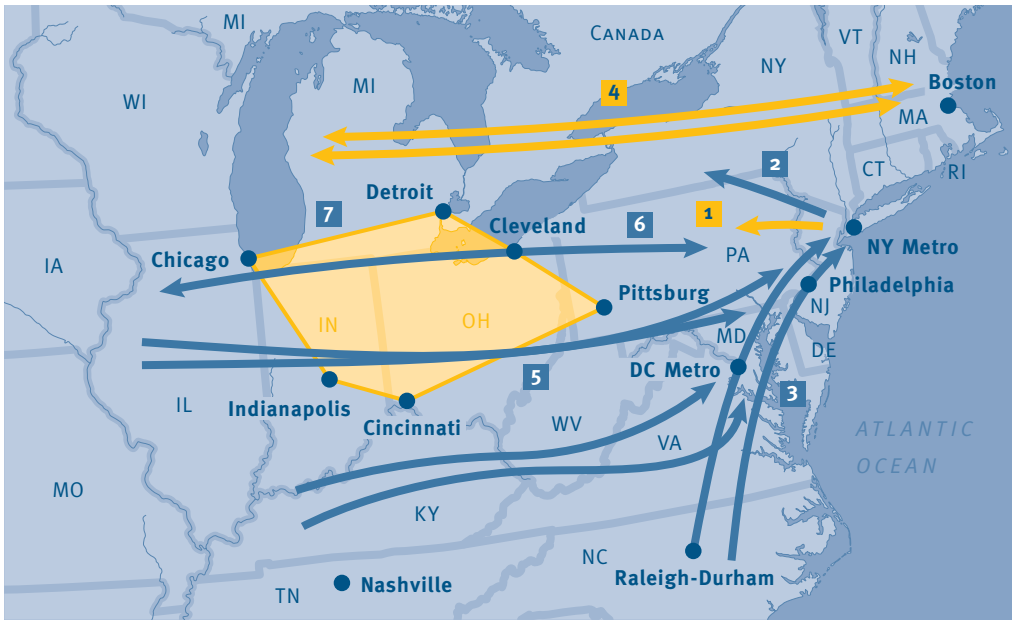


Figure 5-6
National Choke Points

Air traffic control specialists in the regional offices reviewed the problems at the seven choke points and identified a number of possible short-term solutions. In June 2000, the FAA prepared a national action plan to address the choke points. Of the plan's 21 action items, the first 11 were scheduled to be implemented or fully tested by the end of October 2000; the FAA expects to complete the entire choke point initiative by the end of FY 2002. The seven choke points, the problems faced at each, and the first set of action items to relieve the congestion are described below.

1 Westgate departures from the New York airports and west departures from Philadelphia

Flights departing through this choke point are affected by traffic initiatives, holding and departure stops. In addition, departures routed over the ELIOT fix feed three airways and the ELIOT fix is favored for NRP routes. Kennedy and Islip departures feed two airways over the Robinsville fix, near Philadelphia. Dulles and BWI arrivals descend through New York departures.

The FAA is re-routing propeller aircraft and Dulles arrivals, thereby reducing congestion and complexity in this airspace. This action results in fewer departure stops at the New York/New Jersey metropolitan area airports.

2 Northgate departures from the New York Airports and New York ARTCC Sector 34

The Elmira high-altitude sector (ZNY 34) is designed to handle a large volume of traffic flow to the Cleveland ARTCC. North American Route Program (NRP) crossing and converging traffic increases complexity. The result is holding, departure stops and miles-in-trail restriction on departures.

Departure stops from the New York/New Jersey metropolitan area have been decreased by reducing complexity in the high altitude airspace structure north and northwest of New York City.

3 Washington Center (ZDC) sectors at Robinsville, Yardley, and Hopewell

The Hopewell sector (ZDC 16) sequences and separates arrivals to Newark, Kennedy, and LaGuardia, Teterboro, Morrisville, and Philadelphia airports. The traffic flows over Beckley, Flat Rock, and Richmond. The Robinsville sector (ZDC 19) sequences arrivals to the New York TRACON over RBV, and can accommodate only three aircraft in a holding pattern. The Yardley sector (ZDC 18) is fed by one flow from sector 12 with traffic to LaGuardia, Teterboro, and Morrisville. Traffic is held now between 11,000 and 13,000 feet, with the New York TRACON flow at 14,000 feet.

An additional arrival gate into the New York TRACON will increase the throughput and decrease complexity in the mid-Atlantic airspace corridor. Implementation is expected by summer 2001.

4 Jet Route J547 Westbound

This jet route is the major westbound airway from the Boston ARTCC. Normally, traffic to Chicago O'Hare, Detroit, Chicago Midway, and Cincinnati on this route is slowed by miles-in-trail restrictions. Expanded miles-in-trail restrictions result in increased ground and airborne delays. The lack of alternate jet routes limits flexibility.

Flights are now being re-routed from the New England region through Canadian airspace, reducing congestion in en route airspace and providing greater access for New York departures.

5 Great Lakes corridor

When Cleveland ARTCC sectors 48 and 49 provide spacing for flights to multiple airports in the northeast, traffic backs up into the Minneapolis ARTCC, affecting departures from Chicago O'Hare to the south and the east. Indianapolis ARTCC sectors 88 and 89 sequence, space, and hold traffic for St Louis, Chicago O'Hare, Cincinnati, and Detroit. Cleveland ARTCC sectors 66 and 67 impose miles-in-trail restrictions for route J89 westbound, and also provide spacing for the Washington airports and holds for Philadelphia. Traffic must flow around the Buckeye MOA/ATCAA, just northeast of Cincinnati, when the military is using that airspace.

The FAA plans to modify NRP routes east of the Mississippi to reduce airspace complexity. In addition, certain restrictions will be placed on altitudes for short flights, which is expected to improve schedule predictability.

6 High altitude holding of East Coast Arrival Streams

High altitude en route holding of traffic in the Cleveland, Indianapolis, Chicago, and New York ARTCCs, especially traffic to Newark, JFK, Dulles, BWI, Reagan National and Philadelphia. Starts and stops leave sector volumes and capacities unpredictable. This impacts traffic at Chicago O'Hare, Detroit, Cleveland, Pittsburgh, and Cincinnati, incurring delays and unplanned departure stops.

Strategic spacing of aircraft at an earlier point of flights will reduce airspace complexity and the need for holding aircraft in higher altitudes.

7 Departure Access to Overhead Streams

Saturated overhead streams delay flights departing eastbound from Chicago O'Hare, east and southbound from Detroit, and north and eastbound from Cincinnati.

Flights from the Great Lakes region to the New York area will be re-routed through Canadian airspace to improve schedule predictability.

5.3.3 Department of Transportation Initiatives

The Department of Transportation (DOT) has undertaken several initiatives to improve passenger access to the U.S. aviation system. These initiatives involve the FAA but are administered by DOT.

5.3.3.1 One DOT Initiative

DOT recently embarked on a new, intermodal approach to transportation planning, called the One DOT management strategy. The FAA will participate in this program by considering the entire transportation experience of the flying public when determining its investments in airports and other aviation infrastructure. Examples of such initiatives include cooperation between the Federal Transit Authority and the FAA in developing light rail transit systems for JFK International in New York, Lambert Field in St. Louis, and other airports.

5.3.3.2 Federal Railroad Administration High Speed Ground Transportation Initiative

High Speed Ground Transportation, which includes both high-speed rail and magnetic levitation (Maglev), has the potential to alleviate highway and airport congestion. Maglev is a technology in which magnetic forces lift, propel, and direct a vehicle over a guideway. Maglev eliminates contact between the vehicle and the guideway, permitting speeds of up to 300 miles per hour, nearly twice the speed of conventional high-speed rail service. Maglev is expected to be competitive with cars and aircraft for trips in the 100- to 600-mile range.

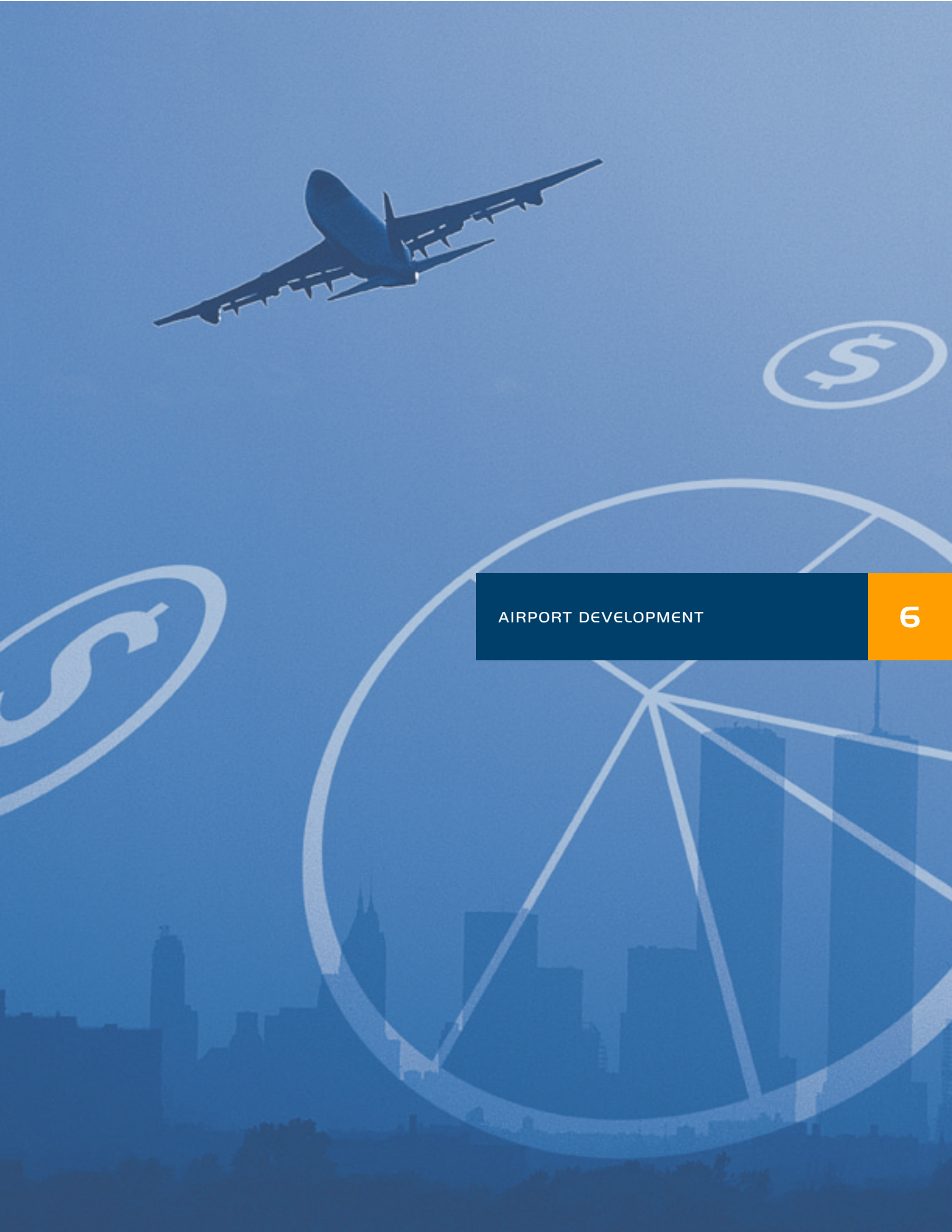
The FAA and the Federal Railway Administration (FRA) recently conducted a study to determine under what circumstances a Maglev project could relieve congestion at one or more large airport. Several criteria were identified as important to the selection of a test airport:

- The airport should be in a densely populated metropolitan area, making major airport expansions unlikely given current environmental constraints.
- The airport should have a high level of connecting traffic, so that the burden of transferring would be no greater for rail passengers than for airline passengers.
- The cost savings from eliminating the delays associated with short-haul flight operations would be large enough to justify the cost of a Maglev alternative.

The FAA evaluated a number of highly congested airports, including Los Angeles, Chicago O'Hare, Atlanta, and Dallas/Fort Worth and selected Los Angeles (LAX) as a possible candidate for a Maglev project. Since more than five percent of LAX's traffic is to and from airports in the Los Angeles metropolitan area, one of those airports, Santa Barbara Municipal Airport (SBA), was selected as the other terminus of the Maglev line. In the summer of 1999, there were 72 daily flights between LAX and SBA.

FRA's Office of Railroad Development requested data from the FAA on the cost of delays imposed by the short-haul flights between LAX and SBA. As part of its ongoing research, the FAA had identified the marginal delay of an additional operation at LAX. The FRA developed a cost of delay model for this study, using the actual fleet mix at LAX to determine the hourly direct operating costs and a representative cost for passenger time. The study found that each short-haul flight imposed a cost of nearly $2,000 on the airport system. The study also estimated the impact of traffic growth and found that if there are no airside improvements at LAX and the number of operations increase by ten percent, the cost of the delay would increase sharply, to as much as $5,000 per flight.

In 1999, the Department of Transportation awarded grants to seven states and local authorities for the pre-construction planning of Maglev projects. These funds will cover up to two-thirds of the cost of the preliminary engineering, market studies, environmental assessments, and financial planning needed to determine the feasibility of deploying a Maglev project. Included among these grants was one in the Los Angeles metropolitan area. Following the preliminary assessments, DOT will choose one of the seven proposals for the construction of a Maglev project.



AIRPORT DEVELOPMENT

6

6 AIRPORT DEVELOPMENT

Expanding the nation's airport infrastructure is the most direct and effective means of ensuring adequate system capacity. Airport development projects, unfortunately, are very expensive. However, in recognition of the importance of new airport infrastructure in alleviating flight delays, recent legislative changes have increased the funding available to airports for capacity enhancement projects.

Local issues also affect airport development. Some of the busiest and most congested airports in the U.S. are located in densely populated areas where airport expansion is difficult because of noise and other environmental issues and limited land availability. In these cases, the FAA and airport operators pursue other measures to increase capacity, such as the development of reliever airports and the modification of operational procedures to use the existing infrastructure more efficiently. The Office of System Capacity (ASC) is instrumental in analyzing traffic patterns at congested airports and recommending modifications to increase capacity.

6.1 Airport Capacity Studies

The Office of System Capacity supports Airport Capacity Design Teams that evaluate alternatives for increasing capacity at airports that already are experiencing significant flight delays. ASC also acts as a team member in other airport capacity projects and participates in air traffic control simulations at the request of local and regional Air Traffic representatives and foreign airport operators.

6.1.1 Airport Capacity Design Team Studies

A typical Airport Capacity Design Team includes FAA representatives from ASC, Air Traffic, the Technical Center and the appropriate region, and representatives from the airport operator, airlines, and other aviation interests. Design Team members propose actions to improve airport capacity and the Technical Center's NAS Advanced Concepts Branch conducts computer simulations of the most promising alternatives. The output of the simulation is an analysis of the impact of each alternative on the operation of the airport.

Upon completion of its study, the Airport Capacity Design Team issues a Capacity Enhancement Plan (CEP) that presents a list of recommended actions and estimates of the impact of each alternative on delays at that airport. The recommendations require additional study before they can be implemented, but over the years, a large number of Design Team recommendations have been adopted by the airport operators, funded by the FAA and other sources, and implemented.

Forty-seven Airport Capacity Design Team studies have been completed and CEPs published. Appendix B lists completed CEPs, their recommendations, and the status of those recommendations (whether they were or were not implemented). The most recent studies of Newark International and Tampa International airports, which were completed in late 1999, the Anchorage Area Airspace Study, completed this year, and the ongoing Portland International Airport study update, to be completed in 2001, are summarized briefly below.

6.1.1.1 Newark International Airport

The Newark International Airport (EWR) Airport Capacity Design Team assessed ways to reduce delays and relieve current and forecast airport congestion. Among the capacity enhancements evaluated were the construction of a new runway and a number of new

approach procedures. The study determined the technical merits of each alternative and its impact on capacity. The analysis showed that at a point in the near future, the greatest savings in delays would be provided by building a new runway that could support independent arrivals in all weather conditions and by permitting immediate divergent turns for propeller-driven aircraft.

Additional studies will be required to assess airspace, environmental, socioeconomic, and political issues associated with these actions. Since all of the capacity enhancement alternatives produced delay savings, the Design Team recommended that each of the alternatives be further studied to determine whether it should be undertaken. The Design Team also concluded that planning for improving Newark's capacity should be undertaken immediately. All initiatives will move on to the next step in the planning process.

6.1.1.2 Tampa International Airport

The study was conducted in conjunction with the airport's master plan update to address the rapid growth in traffic at Tampa International Airport. Tampa is forecast to experience a 24.4 percent increase in operations by 2011. The team focused its analysis on aircraft activity inside the final approach fix and on the airfield. The analysis showed that the greatest savings in delays would be realized through construction of a new runway 17/35 for arrivals that will allow precision approaches to Runways 17, 18R, 35, and 36L.

6.1.1.3 Portland International Airport

Portland International Airport (PDX) ranked 30th in aircraft operations in 1999, but is forecast to experience a 37.9 percent increase in operations by 2011. Based on that forecast, the Portland International Airport Capacity Design Team is conducting an update of their 1996 study. The update will consider the feasibility of constructing a third parallel runway to the south, with associated taxiways, and constructing an additional terminal or expanding the existing terminal. Operational improvements are also being considered. The study update will be released in September 2001.

6.1.1.4 Anchorage Area Design Team Study

The Anchorage Area Design Team Study assessed ways to relieve congestion problems caused by the more than one million annual operations transiting over Point McKenzie. Recommendations included alternative approach procedures to the converging and the closely-spaced parallel runways at Anchorage International Airport. Their analysis of approach procedures determined that there was a need for two IFR streams. The study was completed this year, but additional local studies are still underway. The Anchorage Master Plan will address changes at the airport.

6.1.2 Additional Airport Capacity Activities

ASC is currently a participant on projects involving Dallas/Fort Worth International, Baltimore-Washington International and Washington Dulles International airports.

6.1.2.1 Dallas/Fort Worth International Airport

As of July 1999, regional jets represented just five percent of the commuter fleet at Dallas/Fort Worth International Airport (DFW). The FAA forecasts their numbers to increase significantly as turboprops are replaced, placing additional demand on current jet runways and route structures.

The DFW Airfield Capacity Design Team is currently conducting Phase III of its Airfield Capacity Enhancement Study, an RJ Impact Assessment, to estimate the effect of increased RJ operations under existing airport procedures. The assessment showed an increase in departures on runways 18L and 17R, leading to taxi-in delays for arriving aircraft and taxi-out and ground delays for departing aircraft. Phase IV of the study will review the impact of various capacity enhancement options on the delays and other impacts of the growth of RJ operations.

6.1.2.2 Baltimore-Washington International Airport

Baltimore-Washington International Airport (BWI) is one of the fastest growing airports in the NAS. The FAA forecasts operations at BWI to increase by 36 percent by 2011. Planned improvements include a new 7,800-foot runway 10R/28L, to be constructed by 2008. When the new runway is complete, runway 4/22 will be converted to a taxiway. Operations at BWI will be evaluated during Phase III of the Northeast Regional Capacity Design Study. The Design Team has been working with the Volpe National Transportation Center on this effort.

6.1.2.3 Washington Dulles International Airport

Washington Dulles International Airport (IAD) is also among the fastest growing airports in the NAS, with operations expected to grow by 37 percent by 2011. Several airport improvements are under consideration. A second parallel runway, 12R/30L, has been proposed for a location southwest of runway 12/30, with expected completion by 2002. A north-south parallel runway, 1W/19W, would be located west of the existing parallels and north of runway 12/30. Estimated opening date is 2008. When completed, these runways would provide triple independent parallel approaches.

6.1.3 Air Traffic Control Ground Simulations

ASC is participating in air traffic control ground simulations at Phoenix Sky Harbor International Airport. In addition, because of the FAA's recognized expertise in evaluating capacity enhancements, foreign airport operators have requested assistance. The FAA conducted a ground simulation at Frankfurt International Airport, Germany, in 1999 and at Ben Gurion International Airport in Tel Aviv, Israel in 2000. In both cases, the goal of these activities was to improve the operational efficiencies at these airports. These studies used the Technical Center's Airfield Delay Simulation Model (ADSIM) and the Airspace Delay Simulation Model (SIMMOD) to analyze various airfield configurations and to determine daily total aircraft travel times and ground delays.

6.1.3.1 Phoenix Sky Harbor International Airport

An ongoing initiative to assist Air Traffic with ground operations efficiency is being conducted at Phoenix Sky Harbor International Airport. The goal is to determine a more efficient use of runways for arrival and departure operations, based on both the present runway configuration and several alternate configurations during the construction of a third runway and the subsequent reconstruction of the existing runways. This initiative will be completed in early 2001.

6.1.3.2 Ben Gurion International Airport

The Israel Airports Authority asked the FAA to conduct an analysis of the airspace, airfield, and procedural operations at Ben Gurion International Airport; to assist in making improvement recommendations concerning all areas; and to analyze those recommendations through simulation modeling. The primary airspace recommendation was to create a more efficient northern arrival route to replace the present route from the west. Extension of runway 3/21 to accommodate northern arrivals, new parallel taxiways, high-speed exits, and a new terminal traffic flow were the primary airfield recommendations. Suggested procedural changes included a reduction in the separation standard from five to three miles and simultaneous arrival/departure procedures.

6.2 Funding of Airport Development

Airport development is funded by a combination of public and private sources. Major sources include the Airport Improvement Program (AIP), Passenger Facility Charges (PFCs), state and local funding programs, airport revenue bonds, and airport user charges. Public grants, PFCs, and airport revenue bonds provide most of the capital funding, while user charges generally cover an airport's operating expenses and the debt service for airport bonds.

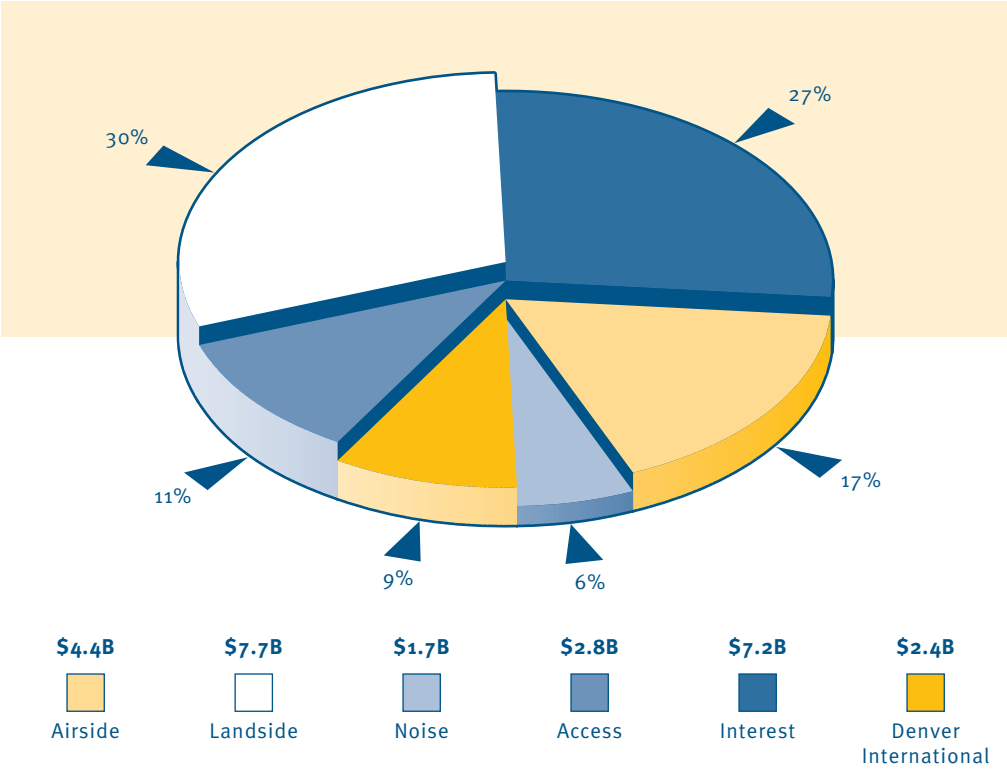
6.2.1 Airport Improvement Program

The Airport Improvement Program plays a critical role in maintaining and expanding the airport infrastructure. AIP provides federal grants for airport development and planning for capital projects that support airport operations, including runways, taxiways, aprons, and noise abatement. Airport sponsors and non-federal contributors must provide at least a ten percent share of any project funded by AIP grants. During the 1990s, AIP grants accounted for between 21 percent and 40 percent of total airport capital development expenditures. AIP funding for FY 1999 was $1.95 billion, with primary airports receiving 26 percent of the total. AIR-21 will provide a substantial increase in AIP funding over the next three years.

6.2.2 Passenger Facility Charges (PFCs)

The recently enacted AIR-21 increased the maximum passenger facility charge that airports can impose on each boarding passenger from $3.00 to $4.50. The increased funding stream from the higher PFCs will result in a significant acceleration of airport construction projects. Since the start of the PFC program, the FAA has approved 872 PFC applications at 316 airports, including 81 of the busiest 100 airports, and total collections of approximately $26.2 billion. Figure 6-1 shows the distribution of those funds by project type. Actual collections in CY 1999 were approximately $1.5 billion.

Figure 6-1
Approved Passenger Facility Charges



6.2.3 User Charges

Airport user charges include aircraft landing fees; apron, gate-use, or parking fees; fuel-flowage fees; and terminal charges for rent or use of passenger hold rooms, ticket counters, baggage claims, administrative support, hangar space, and cargo buildings. Non-airport user charges include revenue from sources such as terminal concessionaire rentals and fees, and automobile parking.

6.2.3 Bonds: Revenue, General Obligation and Special Facility

The issuance of bonds remains the primary means of financing airport development projects at commercial service airports. Bond debt service for interest, capital, and other costs is a major component of airport user charges. Most airport bond financing has used tax-exempt general airport revenue bonds (GARBs).

Terminal facilities have also been financed with special facility bonds. The introduction of PFCs as an additional source of funds has led to the evolution of a version of the GARB that relies partially or totally on PFC revenues for repayment. Because of the conservative nature of the tax-exempt bond market, these PFC-backed bonds often require special commitments from the FAA to reduce the likelihood of any bond default resulting from some federal actions that could affect future PFC collections.

6.2.5 Other Sources of Funding

State and local governments have contributed to the development and operation of community airports, offering matching grants to secure federal support, providing direct grants to fund airport maintenance projects, and financing the installation of navigation aids. To expand air service and to encourage competition, state and local governments have also supported airport marketing initiatives.

6.3 Airport Construction and Expansion

Airport development frequently entails the construction of new terminals, new and extended runways, and improved taxiway systems. In large metropolitan areas with frequent flight delays and limited airport expansion possibilities, other options must be explored. New airports, expanded use of existing commercial service airports, and civilian development of former military bases are options available for meeting expanding aviation needs.

6.3.1 Construction of New Airports

The construction of new airports provides the largest and most significant increase in aviation system capacity. However, given the high cost of construction, the large acquisition and use of land, and environmental impact of an airport, few new airports have been built in recent decades. Among primary airports, only two hub airports have been built: Denver International was completed in 1995 and Dallas/Fort Worth International in 1974. Two primary non-hub airports have recently been completed: Northwest Arkansas Regional Airport and Mid-America Airport. Mid-America is the St. Louis region's second major airport and serves as a reliever airport for Lambert-St. Louis International Airport and as a joint use facility with Scott Air Force Base. The airport opened in June 1998 with a construction cost of $210 million, with a 10,000-foot runway. Mid-America airport recently started scheduled commercial passenger air service.

6.3.2 Conversion of Military Airfields to Civilian Airports

The Military Airport Program (MAP) provides grants to current or former military airfields with the potential to improve the capacity of the NAS. These airfields include Base Realignment and Closure (BRAC) participants, and airfields that have entered joint-use agreements to accommodate civil and military users. Many of these airfields are located near congested metropolitan areas and have the potential to provide capacity gains with relatively small investments by state and local governments.

In 1999, two percent of AIP funds were set aside for the MAP program. Airports remain eligible to participate in the MAP for a maximum of five years. Since 1991, 14 participants have graduated from the program. Two-thirds of the 1999 participants will graduate in 2000. Figure 6-2 lists the 1999 MAP participants.

Civilian Name	Military Name	Location	Airport Type
Austin Bergstrom*	Bergstrom AFB	Austin, TX	Primary
Millington Municipal*	Memphis NAS	Memphis, TN	Reliever
Williams Gateway*	Williams AFB	Phoenix, AZ	Reliever
Alexandria International*	England AFB	Alexandria, LA	Primary
Rickenbacker International*	Rickenbacker AFB	Columbus, OH	Reliever
Sawyer*	K.I. Sawyer AFB	Gwinn, MI	Commercial Service
Southern California Intl	George AFB	Victorville, CA	Reliever
Chippewa County Intl	Kincheloe AFB	Sault Ste Marie, MI	Commercial Service
Pease International Tradeport	Pease AFB	Portsmouth, NH	Planned Commercial Service

* 1999 and 2000 graduates

Figure 6-2
1999 Military Airport Program Participants

The most significant MAP project to date has been the conversion of Bergstrom Air Force Base into a civilian airport, Austin-Bergstrom International. Austin-Bergstrom and two additional MAP projects are briefly described below.

6.3.2.1 Austin-Bergstrom International Airport

Austin-Bergstrom International Airport opened on May 23, 1999, and one year later, passenger traffic showed a 13.63 percent increase over Robert Mueller Municipal Airport's final year of operation. Year-to-date passenger enplanements continue to climb, making it one of the fastest growing major airports in the United States.

6.3.2.2 Alexandria International Airport

The England Authority became the operator of the England Air Force Base when the base closed in December 1992. England Air Force Base was converted and opened as Alexandria International Airport (AEX) in August 1996. Located in the central part of Louisiana, Alexandria International Airport offers convenient transportation for businesses and individuals within a 200-mile radius. With two runways, AEX presently serves commercial, general aviation, and military users, with approximately 55,000 operations and 250,000 passengers per year. AEX has spent over $18.5 million for capital improvements since 1993.

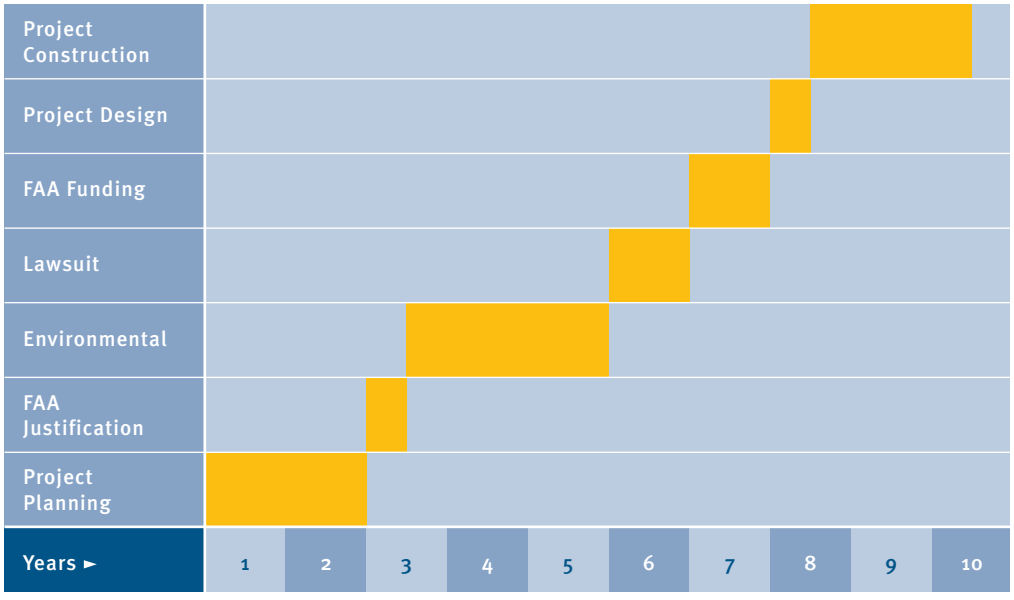
6.3.2.3 Sawyer International Airport

Sawyer International Airport (SAW) opened in 1998. SAW is located near the city of Marquette, Michigan, at the site of former K.I. Sawyer Air Force Base on the southern shore of Lake Superior. SAW presently provides regional air service through three service providers. A crosswind runway is planned to be operational in 2000.

6.3.3 Construction of New Runways, Extensions, Taxiways, and Aprons

Environmental, financial, and other constraints continue to limit the development of new airports. The redevelopment and expansion of existing airport facilities is an important option for airport development. The construction of new runways and the extension of existing runways are the most direct actions to improve capacity at existing airports, but can take a decade or more to complete. Figure 6-3 details the typical process, from planning through construction, for a new runway.

Figure 6-3
Life Cycle of a New Runway



A number of the busiest airports have completed new runways or other runway construction projects in the last six years. Figure 6-4 shows that eight new runways were opened from January 1995 to October 2000. Another 21 runway construction projects were completed, including 15 runway extensions, one renovation, three reconstructions, and two realignments.

Figure 6-4
Completed Runway Construction Projects January 1995 to October 2000

ID	Airport	New	Extension	Renovation	Reconstruction	Realignment	Year	Runway
ABQ	Albuquerque International				•		1995	8/26
CVG	Greater Cincinnati-Northern Kentucky Intl		•				1995	18R/36L
SLC	Salt Lake City International	•					1995	16R/34L
ANC	Anchorage International		•				1996	32
CMH	Port Columbus International		•				1996	28R
DFW	Dallas/Fort Worth International	•					1996	17L/35R
MKE	Milwaukee General Mitchell International					•	1996	7L/25R
MSP	Minneapolis-St. Paul International		•				1996	4/22
OMA	Omaha Eppley Airfield		•				1996	14R/32L
BOI	Boise Air Terminal		•				1997	10L/28R
CMH	Port Columbus International		•				1997	10L
GRR	Grand Rapids Kent County International		•				1997	18/36
IND	Indianapolis International	•					1997	5L/23R
LAS	Las Vegas McCarran International				•		1997	1L/19R
MDW	Chicago Midway				•		1997	4R/22L
SDF	Louisville International	•					1997	17R/35R
GRR	Grand Rapids Kent County International					•	1998	17/35
LIT	Little Rock Adams Field		•				1998	4L/22R
MEM	Memphis International	•					1998	18L/36R
MKE	Milwaukee General Mitchell International		•				1998	7L/25R
MSN	Madison/Dane County Regional	•					1998	3/21
PSP	Palm Springs Regional		•				1998	31L/13R
ABQ	Albuquerque International		•				1999	12/30
AUS	Austin-Bergstrom International			•			1999	17R/35L
GSP	Greer Greenville-Spartanburg		•				1999	3L/21R
PHL	Philadelphia International	•					1999	8/26
EWR	Newark International		•				2000	4L/22R
MEM	Memphis International		•				2000	18C/36C
PHX	Phoenix Sky Harbor International	•					2000	7/25

The busiest 100 airports also have a large number of runway construction projects in progress or in the planning stage. Figure 6-5 lists runway projects with planned operational dates between November 2000 and December 2005. Thirty of the 100 busiest airports have projects in the pipeline, including 14 new runways, 23 runway extensions, and one runway reconstruction. Appendix C shows additional runway construction projects proposed or planned for 2006 and beyond.

Figure 6-5

Runway Construction Projects
November 2000 to
December 2005

ID	Airport	New	Extension	Reconstruction	Runway Identifier	Estimated Cost ($M)	Planned Operational Year	In Progress
PBI	Palm Beach International		•		9L/27R	$ 9.0	2000	•
DSM	Des Moines International		•		5/23	$ 31.0	2001	•
DTW	Detroit Metropolitan Wayne County	•			4/22	$ 116.5	2001	•
ELP	El Paso International		•		4/22	$ 8.0	2001	•
MSP	Minneapolis-St Paul International		•		4/22	$ 7.0	2001	
OGG	Kahului		•		2/20	$ 47.0	2001	
ALB	Albany County		•		10/28	$ 5.8	2002	
BHM	Birmingham		•		5/23	$ 17.0	2002	
CLE	Cleveland Hopkins International	•			5W/23W	$ 467.0	2002	
CLT	Charlotte-Douglas International	•			18W/36W	$ 140.0	2002	
DAY	Dayton International		•		6R/24L	TBD	2002	
DFW	Dallas/Fort Worth International		•		18R/36L	$ 19.0	2002	
IAH	George Bush Intercontinental		•		15R/33L	$ 85.0	2002	
MCO	Orlando International	•			17L/35R	$ 115.0	2002	
PHX	Phoenix Sky Harbor International		•		8L/26R	$ 7.0	2002	•
PNS	Pensacola Regional		•		8/26	$ 12.3	2002	
SRQ	Sarasota Bradenton		•		14/32	$ 5.1	2002	
CVG	Greater Cincinnati-Northern Kentucky Intl		•		9/27	$ 12.0	2003	
DFW	Dallas/Fort Worth International		•		17C/35C	$ 25.0	2003	
IAH	George Bush Intercontinental	•			8L/26R	$ 130.0	2003	
MIA	Miami International	•			8/26	$ 206.0	2003	
MSP	Minneapolis-St. Paul International	•			17/35	$ 490.0	2003	•
DEN	Denver International	•			16R/34L	$ 160.0	2004	
DFW	Dallas/Fort Worth International		•		18L/36R	$ 48.0	2004	
GSO	Greensboro Piedmont Triad International	•			5L/23R	$ 96.0	2004	
IAD	Washington Dulles International	•			12R/30L	$ 217.0	2004	
ORF	Norfolk International	•			5R/23L	$ 100.0	2004	
SAT	San Antonio International		•	•	12L/30R	$ 43.0	2004	
TYS	Knoxville McGhee-Tyson		•		5L/23R	$ 7.0	2004	
ALB	Albany County		•		1/19	$ 7.5	2005	
ATL	Hartsfield Atlanta International	•			9S/27S	$ 450.0	2005	
BOS	Boston Logan International	•			14/32	$ 50.0	2005	
BUF	Greater Buffalo International		•		14/32	$ 4.9	2005	
CLE	Cleveland Hopkins International		•		5R/23L	$ 40.0	2005	
DFW	Dallas/Fort Worth International	•			18R/36L	$ 367.3	2005	
FLL	Fort Lauderdale-Hollywood International		•		9R/27L	$ 300.0	2005	
LBB	Lubbock International		•		8/26	$ 15.0	2005	

AIRSPACE DESIGN

7

7 AIRSPACE DESIGN

This chapter describes the FAA's initiatives to increase airspace capacity by restructuring airspace. Airspace issues may be identified from within the FAA by air traffic controllers or by external sources, such as airlines, airport authorities, or community groups. Problems may also be identified as the result of planned changes to airports, equipment, or traffic patterns. The FAA is now working on several significant airspace initiatives, including the National Airspace Redesign Plan, the consolidation of the Washington area TRACONs, and the continuing development of area navigation routes.

7.1 National Airspace Redesign Plan

The National Airspace Redesign (NAR) will restructure existing domestic and oceanic airspace to increase its efficiency, while maintaining a high level of safety. It will consist of incremental changes to the national airspace structure, consistent with evolving air traffic and avionics technologies. The NAR will initially focus on efforts that can be implemented quickly, provide early user benefits, and set the stage for future developments. That near-term phase will extend from the present to 2002, roughly paralleling Free Flight Phase 1, the mid-term phase from 2002 to 2005, and the long-term phase beyond 2005.

The near-term National Airspace Redesign will be limited by several constraints. First, near-term changes will not include any major modifications of the NAS infrastructure or staffing, such as adding new equipment, building new runways or facilities, or hiring more controllers. Second, the redesign of sectors, routes, and traffic flows will be based on current technology. Finally, any near-term changes must have a neutral environmental impact, i.e., none will be implemented that have a negative effect on noise levels. Given these constraints, the effort should focus on the operational domain that can provide the most benefit in the shortest time. Because en route airspace is generally the least complex, the first redesign efforts will focus on that domain. Initial near-term objectives include the following:

Redesign Traffic Routes

One of the limiting factors of the NAS is that aircraft must generally follow airways that are based on a system of ground-based navigational aids. Following those airways involves flying from one navigational fix to another, connecting a series of doglegs, which increases the distance flown and the time required to do so. The basic premise of Free Flight is that modern avionics and air traffic control technologies can provide more direct routes. These user-preferred routes can be safely flown by aircraft equipped with present day flight management systems (FMS) with certified Required Navigation Performance (RNP) capabilities or area navigation systems such as GPS, and others. The NAR will redesign routes so that suitably equipped aircraft can fly more direct routes between airports.

Review the Present Route Structure and Procedures for Inefficiencies

Current procedures to separate traffic require longitudinal separation of five miles in en route airspace. When two aircraft are flying along the same airway, they are kept in trail, one behind the other, which can delay the trailing plane. If the two aircraft are heading for different airports, it should be possible for them to fly on parallel routes, maintaining safe separation, but enabling both to operate at optimal speed. The NAR will review current procedures and replace them where possible.

Redesign Sectors

Because airspace is divided into sectors that are controlled by different air traffic facilities, aircraft that are flying near or across sector boundaries may be delayed as they are handed off from one facility to another. In the future, advanced on-board navigational capabilities can be used to reduce points of congestion and the need for a large amount of coordination. Sector redesign should take advantage of this capability, which may favor the establishment of a few very large sectors, removing the constraints caused by unnecessary stratification and boundaries. The NAR will review possible redesigns and their step-wise implementation. The first step would be to establish large sectors above FL350, then gradually move the floor lower.

Redesign Traffic Flows

As part of the efforts to analyze existing routes and sectors, traffic flows should be reviewed to determine how well they serve NAS users and what workload they impose on controllers. The NAR will redesign traffic flows to increase their efficiency and to reduce controller workload. This will include the development of procedures for entering and leaving en route airspace that permit optimized climb and descent trajectories.

The completion of near-term initiatives will provide the foundation for the mid-term and long-term phases. To the extent that procedural modifications and airspace re-configurations permit optimized flight in en route airspace, the FAA will be able to reallocate air traffic control resources and personnel to the higher complexity domains, the terminal/airport and transitional control environments.

The natural progression for airspace redesign is for the mid-term phase to address the problems of the transitional control domain, where aircraft climb out of or descend to terminal airport areas, and the terminal/airport domain, where aircraft depart from or arrive at the airport. During this phase, the main areas of analysis and redesign addressed in the en route domain will be improved and gradually expanded into the higher density domains. This expansion will be enabled by technological enhancements such as the Wide Area Augmentation System, the Local Area Augmentation System, Automated Dependent Surveillance-Broadcast, Free Flight Phase 1 demonstration technologies such as the User Request Evaluation Tool, and Free Flight Phase 2 technologies such as Controller Pilot Data Link Communications.

The long-term phase will continue the evolutionary path established in the near-term and mid-term phases. It will include the implementation of additional capabilities that are described in the FAA's NAS Architecture. The NAR will use these and other technological enhancements to continue the redesign of routes, sectors, and traffic flows that began in the near-term phase.

7.2 Consolidation of Terminal Radar Approach Facilities

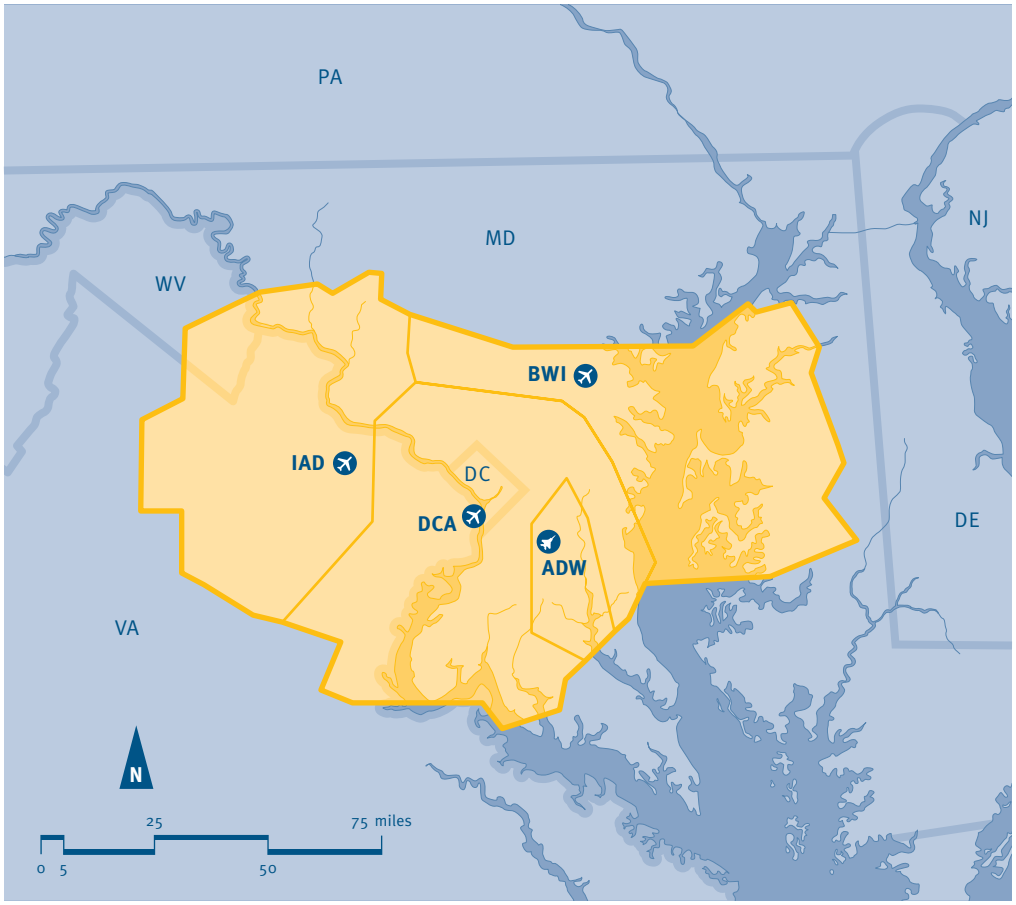
Terminal airspace extends from five to 20 miles from an associated airport. In metropolitan areas with several airports, the terminal airspace of adjacent airports may overlap, creating a complicated airspace structure. In these circumstances, consolidating two or more TRACONs into a single facility can simplify that airspace structure. The consolidation improves communications among controllers handling operations over a wide geographic range and increases their flexibility in merging, maneuvering, and sequencing aircraft to and from the area airports.

The FAA has undertaken a number of major TRACON consolidations in the past few years, the most recent being the Southern California TRACON, which combined the operations of five TRACONs in the Los Angeles-San Diego area into a single facility (Burbank, Los Angeles, Ontario, Coast, and San Diego). Other significant consolidations are planned in Atlanta, Northern California, and the Washington/Baltimore metropolitan area. The consolidation of the four Washington TRACONs provides an excellent example of the problems of complicated terminal airspace and the benefits of consolidation and airspace redesign.

7.2.1 The Potomac Consolidated TRACON

The Washington/Baltimore metropolitan area is served by four major airports: Reagan Washington National (DCA), Dulles International (IAD), Baltimore-Washington International (BWI), and Andrews Air Force Base (ADW). These four airports are close together, located within a geographic area that in many places would be served by a single airport. The existing airspace configuration of the four TRACONs is shown in figure 7-1.

Figure 7-1
Terminal Airspace in the Washington/Baltimore Area



A TRACON's airspace is subdivided into smaller sections called sectors. Each sector is assigned to an individual air traffic controller, who monitors the movement of aircraft into and out of the sector on a radar screen and provides instructions to pilots via radio. Although a controller is only responsible for aircraft in that sector, each controller within a TRACON has full radar information on all the aircraft in that airspace and can easily communicate with other controllers, as needed. However, controllers in adjacent TRACONs have only a limited ability to communicate regarding the aircraft that pass from one area to another.

In the Washington/Baltimore area, the responsibility for handing off departures from terminal airspace to the centers is assigned to specific TRACONs, based on the direction of each flight. For example, the Washington TRACON coordinates the hand-off of southbound departures from each airport's terminal airspace to the Washington en route center. The Dulles TRACON is responsible for most west and northwest jet traffic and the Baltimore TRACON is responsible for propeller traffic to the east and northeast.

Departures also need significant vectoring to sequence them for hand-off to the appropriate centers, which requires coordination among the TRACONs. For example, controllers from three of the TRACONs must coordinate each aircraft that departs southwest from BWI prior to it being handed off to the Washington center. Thus, one relatively simple procedure requires the involvement of four controllers. Similarly, arrivals also require coordination among the TRACONs. The New York and Washington centers manage arrivals to the Washington airports as a series of single streams, separating them by destination only as each flight descends into terminal airspace. But because of the complexity of the terminal airspace, more than one TRACON is usually involved. For example, some DCA arrivals from the west are routed through the Baltimore TRACON before they are passed to the Washington TRACON.

The Potomac consolidated TRACON (PCT) will combine the four area TRACONs into a single new facility. The FAA expects to commission the new facility in May 2002. Approximately one year after PCT is commissioned, the Richmond TRACON will be added to the consolidated facility. The contiguous PCT airspace will improve routing efficiency during normal operations and will also provide controllers with additional options for directing departures and arrivals during periods of adverse weather. The new PCT will permit a complete restructuring of air traffic services for the Washington/Baltimore area. The facility will be able to provide approach control functions to all area airports using a single set of procedures. Streamlined and centralized traffic management will result in the elimination of extraneous coordination and unnecessary restrictions and allow for the improvement of procedures and resectorization that is not possible in the current environment.

The consolidated TRACON, capitalizing on the availability of a new automation system to process additional long- and short-range radars, will have continuous radar coverage from south of Richmond to north of Philadelphia and from as far west as Harrisburg, Pennsylvania to east of Patuxent, Maryland. The additional terminal airspace will increase efficiency by providing more flexibility to the PCT and surrounding ARTCCs when setting up arrival and departure routes. Using terminal separation standards of three nautical miles (compared to the five nautical miles required in ARTCC airspace) and the benefits of residing in a single facility, the PCT will be able to handle inbound and departing aircraft more efficiently. The proposed airspace changes are the subject of an ongoing environmental impact study (EIS) analyzing traffic patterns and alternatives with the goal of increasing air traffic system efficiencies, enhancing the safety of flight, and reducing aircraft noise exposure to the public. The draft EIS is expected in May 2001. The new airspace design will be implemented by March 2003, approximately one year after the PCT is commissioned.

7.3 Area Navigation Route Development

Area Navigation (RNAV) refers to any instrument navigation performed outside of the conventional routes defined by the position of ground-based navigational aids or by intersections formed by two navigational aids. Technologies such as Flight Management Systems, LORAN-C, and inertial guidance systems have offered RNAV capability to aircraft for

nearly two decades. With the introduction of relatively inexpensive GPS avionics in the 1990s, more aircraft are now acquiring RNAV capability. Aircraft with RNAV equipment can navigate point-to-point, eliminating the doglegs that result from using the ground-based navigational aids. The FAA is developing RNAV routes in a number of projects focused on the transition from the current ground-based navigational system to a satellite-based system. Several of these projects are described below.

7.3.1 The Atlantic High Class A RNAV Project

Since its inception, area navigation has increased the ability of the pilots to overcome aviation system constraints in areas of limited surveillance and navigational aid coverage. The Atlantic High Class A RNAV route project (formerly the Caribbean RNAV route project) was conceived in 1995 by the Miami ARTCC and the Southern Region as an alternate means of handling air traffic in U.S. offshore Class A airspace between Florida and Puerto Rico. Air traffic in this region has been increasing steadily, but the lack of ground-based navigational aids and limited radar surveillance has substantially restricted airspace capacity. The objective of this project was to develop an RNAV route system to supplement the current airway system and to increase capacity by reducing spacing requirements.

Phase 1 was initiated in October 1997 with the implementation of 13 advanced RNAV routes. At a May 1998 project status meeting, airline participants reported fuel and time savings from using the RNAV routes. Those airlines and controllers recommended reducing the number of routes to six and realigning them, while agreeing that additional routes would be developed later. The six revised routes (referred to as "T routes") were implemented in December 1998 for use with radar coverage. The routes are eight nautical miles wide, with at least two nautical miles between parallel routes. Unlike routes based on VORs, which widen at distances exceeding 51 nautical miles from the site because of the degradation of the signal, the RNAV routes maintain a constant width, which increases available airspace capacity.

Phase 2, which extended the authorized use of the RNAV routes to times of radar outages, began in late 1999. Nine airlines are participating in this RNAV route project and seven more are expected to participate when their aircraft are properly equipped and their crews are trained. Figure 7-2 shows the coverage of the Atlantic RNAV routes.

Figure 7-2
Atlantic RNAV Routes

7.3.2 Advanced Navigation Routing Project

The FAA New England and Eastern regions are developing RNAV preferential routings to eliminate the doglegs (indirect routes) that result from using ground-based navigational aids. This project, referred to as the Advanced Navigation Routing Project, began in the New England region with the design of direct preferential routes between departure and arrival fixes and the design of overlays of existing routes. Because existing fixes were not sufficient to provide the most direct routes, the FAA developed four off-airway fixes. These fixes provide the most efficient arrival and departure points for a number of route adaptations.

The host computer software at the Boston ARTCC was also modified to enable the computer to identify RNAV-equipped aircraft so that they can be provided with the preferential routings. The host computer software modifications are being extended to ARTCCs nationwide, which will facilitate the development of RNAV routing capability across the U.S.

There are now 70 RNAV routes in the New England region, and seven test routes between the Eastern and New England Regions under development. Figure 7-3 depicts two examples of RNAV routes in the Northeast that now allow pilots to fly more direct routes between their departure and destination points. Computer modeling of 700 flight plans on the initial 36 RNAV routes indicated an average savings of one minute and five nautical miles per flight, which equates to a one percent reduction in distance and two percent reduction in time, and annual user savings of $8.2 million. Controllers reported that the test routes resulted in fewer traffic conflicts and instances of sector loading, contributing to the efficiency and safety of the air traffic system.

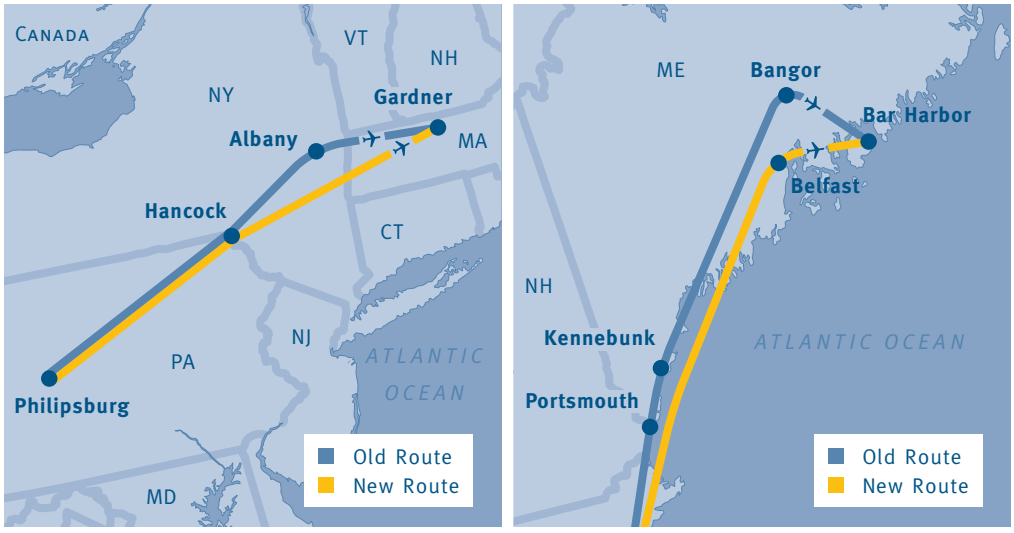


Figure 7-3
Savings from RNAV Routes

The Advanced Navigation Routing Project has expanded beyond the New England Region. The preferential routes were designed point-to-point between departure and arrival fixes or were designed to overlay an existing portion of a route to eliminate doglegs. All test routes were computer modeled. The computer simulation model determined the impact to the system and confirmed user and controller benefits. A local automation change to the Boston ARTCC's HOST computer was also developed. The HOST change identifies and segregates advanced navigation aircraft (equipment codes E, F, and G) to use HOST preferential routings not limited by surface navigation aids. Since existing fixes were not sufficient to provide the most direct routings, development of four off-airway fixes was required. These fixes help provide the most efficient arrival and departure points for over 75 terminal and en route

preferential route adaptations. There are now 70 New England Air Traffic advanced navigation routings. The Eastern Region has taken the lead in expanding advanced navigation routings and there are seven test routes between the Eastern and New England Regions.

7.3.3 Southern Region RNAV Routes

A multiple-center study is underway in the FAA's Southern Region, with the objective of creating RNAV routes between Atlanta, the central Florida complex of airports (Tampa, Orlando, Daytona Beach, and Jacksonville), and Miami. Airspace in the Miami, Jacksonville, and Atlanta ARTCCs' airspace is being redesigned for use by aircraft equipped with advanced navigation systems. Ultimately, user-preferred routes will connect departure runway ends to the arrival runways via transition waypoints. In effect, RNAV departure/arrival corridors will be created to integrate aircraft to and from en route airspace.

In September 1998, departure and arrival transition way points were established for Atlanta, Daytona Beach, Jacksonville, Orlando, Tampa, and Miami terminal areas, and en route way points were established for the Jacksonville center. In September 1999, the en route portion of the RNAV routes was modeled to determine potential controller workload and possible sector redesign. The analysis found that the present sector design is adequate for the successful implementation of this project. Full implementation is scheduled for January 2001.

7.3.4 Gulf of Mexico Helicopter Procedural Initiative

In October 1998, IFR helicopter operations in the Gulf of Mexico began operations under the GPS Grid System, replacing the system that used LORAN-C and radials from shore-based VORs. The Helicopter Safety Advisory Conference, the Southwest Region Air Traffic Division and the Houston ARTCC collaborated on this project.

The previous system often took helicopters as much as 40 nautical miles out of their way, was labor intensive for controllers and pilots, and caused expensive delays (IFR delays cost the users approximately $350,000 per hour). The new system uses GPS navigation to create a Free Flight environment, resulting in substantial fuel and time savings. The use of the Grid System offers a significant capacity increase in IFR operations per hour, reduces delays, and enhances safety.

OPERATIONAL PROCEDURES

8

8 OPERATIONAL PROCEDURES

The FAA develops new operational procedures to implement changes in airspace design or to modify existing structures. New operational procedures can increase airspace capacity with little or no investment in airport infrastructure or equipment. The FAA does this by giving pilots more flexibility in determining their routes, altitude, speed, and departure and landing times.

This chapter describes a number of projects that are under way. Many of these projects will take a number of years to be completed, but nonetheless have an impact on system capacity and efficiency.

8.1 Reduced Oceanic Separation Standards

A fundamental difference between oceanic airspace and airspace over land is that aircraft over the oceans have to be given greater separation from each other because of the absence of radar coverage. The current oceanic air traffic control system uses filed flight plans and position reports to track an aircraft's progress and ensure that separation is maintained. The progress of an aircraft is monitored by air traffic control using position reports sent by the aircraft over high frequency radio. Position reports are infrequent (approximately one per hour). Radio communication is subject to interference, disruption, and delay because radio operators are required to relay messages between pilots and controllers. These deficiencies in communications and surveillance have necessitated larger separation minima.

Reduced separation standards are being implemented over a period of time in different areas of oceanic airspace to take advantage of technological advances that are improving the accuracy and timeliness of position information available to pilots and air traffic controllers. At this time, vertical separation minima are being reduced in both the Atlantic and in the northern Pacific, while horizontal separation minima are being reduced in the Pacific.

8.1.1 Reduced Vertical Separation Minima in the Atlantic and Northern Pacific

Procedures implemented more than 40 years ago require a 1,000-foot minimum vertical separation between IFR aircraft below FL290 and a 2,000-foot separation above FL290. The 2,000-foot separation above FL290 was necessary because the instruments used to display, report, and control aircraft altitude at that time had relatively poor accuracy.

Over the past few years, the FAA, in cooperation with ICAO and international air carriers has begun reducing oceanic vertical separation minima from 2,000 feet to 1,000 feet. The goal of this initiative, called Reduced Vertical Separation Minima (RVSM), is to increase airspace capacity and allow more aircraft to operate at fuel-efficient altitudes. Reducing vertical separation from 2,000 feet to 1,000 feet effectively doubles the number of available routes.

To ensure that aircraft will be able to maintain separation, aircraft that want to participate in RVSM must meet stringent altimetry system standards. Height-keeping performance of participating aircraft is monitored under two main airways, using aircraft radar returns. Aircraft that do not pass through those monitoring areas are evaluated using portable measuring devices.

RVSM is being phased in by altitude and airspace region. It was pioneered in the North Atlantic airspace. Aircraft crossing the North Atlantic fly along a highly organized route structure. Traffic flows primarily westbound from Europe in the morning and eastbound from North America in the evening. RVSM was implemented in the North Atlantic airspace from FL330 to FL370 in 1997 and was expanded to FL310 to FL390 in 1998.

RVSM in the North Atlantic has successfully increased capacity and resulted in user-estimated fuel savings of $32 million annually. Full implementation of RVSM for FL290 to FL410 should be complete by 2001.

RVSM in the Western Atlantic for FL310 to FL390 will be phased-in starting in 2000, beginning with traffic en route to or from airspace in which RVSM is already in effect. The Western Atlantic route system is a complex web of fixed routes that frequently experience high traffic volume. The heaviest traffic flow is North-South from the United States to Puerto Rico. Preliminary estimates of fuel savings due to RVSM in the Western Atlantic are one to two percent. Full implementation of RVSM in this region is scheduled for 2001.

RVSM was implemented in the Northern Pacific from FL290 to FL390 in 2000. Projected fuel savings for U.S. carriers as a result of RVSM in this region are expected to exceed $150 million.

8.1.2 Reduced Horizontal Separation Minima in the Pacific

As a result of improved navigational capabilities made possible by technologies such as GPS, TCAS, and controller-to-pilot data link communications, oceanic horizontal separation standards, both lateral and longitudinal, are being reduced.

Oceanic lateral separation standards were reduced from 100 to 50 nautical miles in the Northern and Central Pacific regions in 1998, and in the Central East Pacific in 2000. The FAA intends to extend the 50 nautical mile separation standard to the South Pacific. Flights along the Southern Pacific routes are frequently in excess of 15 hours. As a result, the fuel and time savings resulting from more aircraft flying closer to the ideal wind route in this region are expected to be substantial.

In 1998, longitudinal separation minima were reduced in the Northern Pacific from the time-based standard of 15 minutes to 50 nautical miles. This procedure requires controllers to obtain the aircraft position every 30 minutes. Until enhanced surveillance capabilities are available, this standard will be limited to the Pacific region.

8.2 Increasing Civilian Access to Special Use Airspace

The FAA routinely works with the Department of Defense (DoD) to provide civilian access to special use airspace (SUA) when it is not being used by the military, through agreements concerning civilian access to specific SUA and the development of automated information systems that report on the availability of SUA.

One example is the agreement between the FAA and DoD on civilian access to off-shore SUA along the West coast and the FAA has developed routes that take advantage of the increased access. The Pacific-offshore route, which ranges from San Francisco to San Diego, helps reduce departure delays at San Francisco International Airport. The Point Mugu Oceanic Access Route allows for bi-directional flows from Los Angeles-area airports and direct western access to oceanic airspace. Both of these routes are available at all times unless required for military use. Figure 8-1 shows the Pacific-offshore route.

Figure 8-1

Special Use Airspace Routes Along the West Coast

Aircraft are normally sent over, under, or around special use airspace. By gaining access to SUA status information, pilots can sometimes avoid these deviations, saving both fuel and time. Increasing access to special use airspace is a key component of Free Flight and an important capacity enhancement.

In cooperation with DoD, the FAA has developed a computer information system, the Special Use Airspace Management System (SAMS) to provide pilots, airlines, and controllers with the latest status information, current and scheduled, on special use airspace. DoD operates a similar system, the Military Airspace Management System (MAMS) to prepare and transmit their schedules to the FAA. The FAA redistributes this information via SAMS.

The Central Altitude Reservation Function (CARF) is another FAA component supporting military operations. SAMS handles schedule information regarding "fixed" or "charted" SUA while CARF handles ad hoc time and altitude reservations. Both subsystems deal with planning and tracking the military's use of the NAS.

As part of the FAA Spring/Summer Plan, the FAA and the U.S. Navy have signed a letter of agreement regarding civilian use of offshore warning area airspace from Northern Florida to Maine during severe weather events. The letter specifies coordination procedures to ensure that flights may be routed through this airspace when required to circumvent severe weather. To facilitate the use of this airspace, the FAA established waypoints in East Coast-offshore airspace along several routes for conducting point-to-point navigation when the DoD has released that airspace to the FAA. The waypoints take advantage of RNAV capabilities and provide better demarcation of airspace boundaries, resulting in more flexible release of airspace in response to changing weather.

8.3 RNAV Approaches

Global Positioning System navigation is revolutionizing aviation as satellite guidance makes new instrument approaches to many more airports possible. The FAA has developed new terms and standards for instrument approaches grouped under the general category of RNAV to capitalize on GPS capabilities. RNAV approaches increase system safety by allowing more stable descent paths than instrument approaches using traditional ground-based navigational aids and also offer capacity benefits, particularly at airports that did not previously offer instrument approach capability. The FAA is developing RNAV approach procedures at airports across the U.S., and is publishing them in new instrument approach charts intended for all aircraft. The new RNAV instrument approach charts include lateral navigation (LNAV) and lateral navigation/vertical navigation non-precision approaches (LNAV/VNAV).

An LNAV approach is a non-precision approach (no vertical guidance) with a minimum descent altitude of 250 feet above obstacles on the flight path. LNAV approaches can be conducted today with approach-certified GPS receivers. The FAA has developed 2,833 LNAV approaches at general aviation airports, almost forty percent of which are at airports that previously had no straight-in instrument approach capability.

An LNAV/VNAV approach is a vertically-guided approach with a decision altitude down to 350 feet above the runway touchdown point, requiring a Wide Area Augmentation System (WAAS) certified receiver (not yet available) or certain flight management systems (FMS) with barometric VNAV. Visibility requirements are generally one mile at airports without approach lighting systems. The LNAV/VNAV procedure falls between a non-precision approach with no vertical guidance and a true precision approach. It may not have the same level of accuracy, integrity, and continuity as an ILS, but it provides very good vertical guidance, stabilizing the approach. As such, the development of LNAV/VNAV approaches is a strategy to help reduce the risk of controlled flight-into-terrain at airports without an ILS, or when an ILS is out of service. In addition, the development of these approaches at airports that do not currently have an ILS increases access to these airports under low-visibility conditions. The FAA has published 115 LNAV/VNAV approaches.

The new RNAV approach charts will also include precision approaches using WAAS when it becomes operational. WAAS was intended to allow ILS-like CAT I approaches to 200-foot decision altitude and one-half mile visibility at airports with the appropriate lighting systems and runway markings. Although system accuracy has consistently exceeded CAT I standards in recent tests, system integrity has not yet met certification standards. Integrity describes the system's ability to detect a problem with the navigation signal and warn the pilot quickly.

It is unclear when WAAS will be able to provide CAT I capabilities, but WAAS is expected to deliver LNAV/VNAV approaches to the majority of U.S. airports by 2002. The availability of LNAV/VNAV approaches made possible by WAAS will greatly increase safety and access at smaller airports that do not have instrument approaches with vertical guidance.

8.4 Removal of 250-Knot Speed Limit

Aircraft are currently restricted to a speed of 250 knots below 10,000 MSL, which limits departure rates from busy terminal areas. In 1997, the FAA conducted a field test for departures from Houston Class B airspace to evaluate the impact of removing the 250-knot speed limit. The results of the test were generally positive. The majority of pilots and controllers who were interviewed supported the concept and the surrounding communities perceived no noise impact from removing the speed limit. However, removing the speed limit appeared to result in an increase in the number of aircraft exiting Class B airspace below 10,000 feet, raising the possibility of increased risk of collision with uncontrolled traffic passing just outside of the Class B airspace.

An analysis of radar tracks of flights involved in the field test revealed that older aircraft were more likely to exit the Class B airspace prior to reaching 10,000 feet. Subsequent tests revealed that appropriate pilot techniques, such as use of higher power settings and reconfiguration of the aircraft allowed flights to reach 10,000 feet prior to exiting Class B airspace at speeds up to 300 knots.

A determination of required pilot training, system modifications, and further analysis must be made before implementing the procedure at additional airports. Possible system modifications include establishing climb corridors in high-density traffic areas and annotating departure procedures to describe the actions required to ensure that aircraft reach 10,000 feet prior to exiting the Class B airspace.

8.5 Simultaneous Offset Instrument Approaches

A combination of technology and procedures called Simultaneous Offset Instrument Approaches (SOIA) has the potential to increase capacity at airports with closely spaced parallel runways. Using a precision runway monitor (PRM) and an offset ILS localizer and glide slope, SOIA can safely reduce approach minima from 3,500 to 1,600 feet and visibility minima from five to four miles.

Using a SOIA, the pilot on the offset approach would fly a straight-but-angled approach until descending below the cloud cover. At that point, the pilot would have a period of time to visually acquire the traffic on the other approach before continuing to the runway. If the pilot does not see the other aircraft before reaching the missed approach point, the approach must be discontinued.

SFO is the first candidate airport for SOIA. SFO has purchased a PRM, which is expected to be operational by late 2001. At SFO the arrival rate is 60 aircraft per hour in clear weather, using both parallel runways, which are 750 feet apart. In low-ceiling conditions, simultaneous visual conditions cannot be conducted. Aircraft are placed in-trail to one runway, reducing the airport arrival rate by half. SOIA would allow the airport to increase its airport acceptance rate during adverse weather to 38-45 aircraft per hour. Other potential sites for SOIA include St. Louis and Newark airports.

An evaluation of the flyability of the SOIA procedure conducted in July 1999 concluded that the procedure meets the design criteria for flyability and that the collision risk between the two aircraft was negligible. The FAA is now evaluating wake vortex issues and determining how the procedure could be modified to minimize risk of a wake vortex-related incident.

8.6 Increased Use of Land and Hold Short Operations

More than 30 years ago, the FAA began allowing simultaneous operations on intersecting runways, under restricted conditions, at a number of U.S. airports. Using this procedure, an air traffic controller could clear an aircraft to land and stop before a designated "hold short" point to allow another aircraft to take off or land on the intersecting runway. This procedure increases airport acceptance rates by capitalizing on the fact that the full runway length is not necessarily required for an aircraft landing.

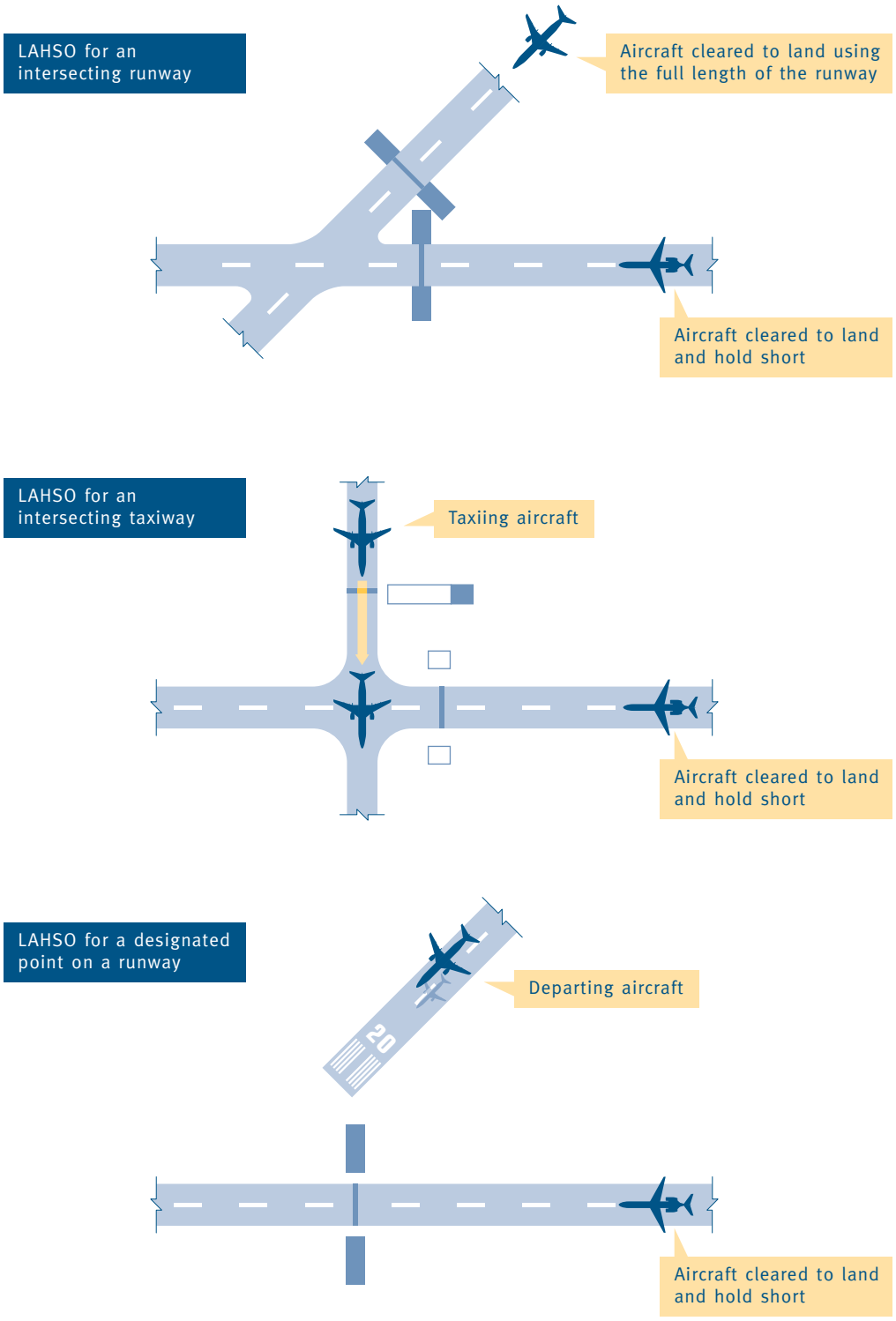
In 1997, the procedure was expanded to include landing and holding short of an intersecting taxiway, approach/departure flight path, or predetermined point on the runway other than a runway or taxiway, under the designation land-and-hold-short operations (LAHSO). The pilot-in-command has the final authority to accept and decline any LAHSO clearance.

In February 1999, the FAA, in coordination with the Air Transport Association (ATA) and the Air Line Pilots Association (ALPA), made a number of changes to the LAHSO procedure, such as limiting LAHSO to dry runway conditions. In August 2000, the FAA issued revised standards containing three additional substantive changes. First, the means of determining the minimum available landing distance was modified so that the longest-possible landing distance plus an additional safety margin will be used to determine whether LAHSO can be conducted for a given aircraft at a specific runway. Next, the new standards allow participation in LAHSO only by pilots who have been adequately trained in the maneuver. While most air carrier pilots have already been trained in LAHSO, the FAA will ensure that the remaining air carrier pilots, and GA and foreign carrier pilots, receive adequate training. Mixed U.S. air carrier/GA/foreign operations will be permitted only when adequate pilot training is accomplished. Also, no LAHSO will be conducted on runways that require a rejected landing procedure until the procedure has been scientifically modeled and verified.

This last requirement will have a noticeable adverse impact on capacity, at least temporarily, at certain large airports. At the 19 largest U.S. airports, 39 intersecting runways where LAHSO was previously conducted require a rejected landing procedure. For example, previously about a quarter of Chicago O'Hare's daily operations were conducted on two intersecting runways (14R and 27L) in rapid succession when weather conditions permitted. Arriving planes on runway 14R stopped short of the intersection when an aircraft was departing on runway 27L. Because it requires a special rejected landing procedure, LAHSO will not be available for this particular runway combination until the procedure has been modeled and verified, which will reduce daily operations at Chicago O'Hare by approximately ten percent. Other airports where the new rejected landing procedure requirement will have a significant impact on capacity include Boston, Philadelphia, and St. Louis. Figure 8-2 illustrates the LAHSO procedure for an intersecting runway, taxiway, or pre-determined point on the runway.

Figure 8-2

LAHSO Takeoff and Landing Procedures



NATIONAL AIRSPACE SYSTEM MODERNIZATION

9

9 NATIONAL AIRSPACE SYSTEM MODERNIZATION

NAS Modernization is the FAA's long-term plan to meet the growing demand for air traffic services. The concept of Free Flight is the impetus for many of the changes of NAS Modernization. Free Flight will give pilots greater flexibility in determining their routes and speeds. NAS users will face fewer restrictions in their flight operations resulting in lower operating costs and fewer delays.

The myriad projects of NAS Modernization, and their interrelationships, are described in detail in the NAS Architecture. The NAS Architecture was released as a living database in April 2000 and reflects the latest results of ongoing research, development of technologies, and changes in funding. The Architecture database provides a service-based view of the NAS.[7] This chapter summarizes the programs that support NAS services and describes the initiatives that are already underway.

Because the FAA's air traffic control system operates continuously, most changes, from the installation of new equipment to the implementation of new procedures, will take place while aircraft are using the system. Maintaining the system's level of safety under these conditions requires careful planning and execution. Therefore, NAS Modernization has been designed as an evolutionary process that will sustain current NAS operations while new technologies are introduced, proven, and then deployed. This process will allow for a smooth transition from one technology to another, sufficient time for users to equip, and realistic schedules for service providers to test, train for, and deliver services. NAS Modernization is divided into three phases, from 1998 to 2015:

Phase 1 (1998-2002)
Focuses on sustaining air traffic control services and delivering early benefits; satellite-based navigation systems will be deployed and air-to-air surveillance will be introduced.

Phase 2 (2003-2007)
Concentrates on deploying the next generation of communications, navigation, and surveillance (CNS) equipment and the automation upgrades necessary to accommodate new CNS capabilities.

Phase 3 (2008-2015)
Completes the required infrastructure and integration of automation advancements with new CNS technologies that will enable Free Flight capabilities throughout the NAS.

9.1 Milestones in NAS Modernization

NAS Modernization is a complex undertaking that cannot be adequately described in this plan. Readers interested in the details of modernization should consult the full NAS Architecture. This chapter highlights milestones that have been recently achieved and important projects that are already underway.

Milestones include the full deployment of the Display System Replacement System, the replacement of the HOST computer with new computers, and the completion of the

7 The complete NAS Architecture 4.0 and a summary called the Blueprint for NAS Modernization are posted on the FAA web site at www.faa.gov/nasarchitecture. The architecture database can be accessed through the Capability Architecture Tool Suite.

Common ARTS radar program. Ongoing projects include the new technologies of Free Flight Phase 1, their expansion under Free Flight Phase 2, and Safe Flight 21.

9.1.1 Full deployment of The Display System Replacement

The FAA dedicated the final Display System Replacement (DSR) on July 14, 2000, at the Leesburg ARTCC. The first major component of the FAA's modernization of the nation's en route air traffic control system infrastructure, the DSR program was completed on time and within budget, and the new equipment is now operational at all 20 ARTCCs.

DSR updates the en route air traffic control systems computer and display equipment. It replaces 20- to 30-year old equipment that was declining in reliability and increasingly expensive to maintain. Monochrome circular radar screens have been replaced with 20 x 20-inch, high-resolution color monitors to display radar tracks and other air traffic information, while the computers have greatly increased data processing capability. DSR provides high reliability and availability through hardware redundancy, fault-tolerant software design, and primary and backup networks.

DSR has an open architecture that can accommodate software upgrades and new technologies. This means that DSR will be a cost-effective platform for future upgrades to air traffic control capabilities. Early improvements will include the Voice Switching Control System digital communication system and the User Request Evaluation Tool and other Free Flight Phase 1 technologies.

The success of DSR validates the FAA's revised approach to modernization: acquiring new systems by using an incremental approach rather than tackling large, complex projects all at once. With DSR, the FAA concentrated on replacing the controllers' workstations and other supporting equipment and plans to add new functions and capabilities later. In implementing DSR, the FAA also worked actively with internal users (controllers and maintenance technicians) and with external users (the airline industry) to make decisions more collaboratively.

9.1.2 HOST and Oceanic Computer Replacement

The HOST and Oceanic Computer System Replacement (HOCSR) program has replaced existing computers at the 20 ARTCCs. The new equipment replaced rooms full of older, far less capable hardware that had been deployed in 1986 through 1988 as an interim upgrade (the new computers reduce required facility space from 900 to 74 square feet). Many of the hardware components had reached the end of their commercial lives. The new HOCSR computers should be in use until at least 2008. The new system has extremely high reliability, significantly improved maintainability, and more complete backup than the equipment it replaces.

The en route center automation system is the foundation of the FAA's automated air traffic control environment. It receives, processes, coordinates, distributes, and tracks information on aircraft movement throughout the nation's airspace. The HOCSR computers process incoming data and provide it to the new DSR multicolor displays. The computers also connect to other FAA services, including air traffic control towers, flight service stations, adjacent flight information regions, other centers, and to external organizations such as the U.S. Customs Service and the military.

The first HOCSR reached its initial operational capability at the New York ARTCC early on January 24, 1999, declared operationally ready February 1999, and dedicated in March 1999. Subsequent installations proceeded rapidly and the final installation took

place in January 2000. The new system has already been upgraded. The software has been upgraded to allow the FAA to fully exploit the system capability of the new platform that had been installed in HOCSR Phase 1. The Phase 2 software improvements were operational at 22 of the 23 sites in September 2000.[8] The HOCSR team is currently conducting engineering analyses and developing detailed schedules in preparation for HOCSR Phases 3 and 4 activities to replace critical peripherals.

9.1.3 Common Automated Radar Terminal System

The Common Automated Radar Terminal System (ARTS) Program was recently completed with the commissioning of the Huntington, West Virginia site. Common ARTS is now fully operational at all 133 ARTS IIE sites (small-to-medium TRACONs) and at 5 ARTS IIIE sites (at the large TRACONs at Ft. Worth, New York, Chicago, Southern California, and Denver). Common ARTS will remain the primary terminal automation system until it is replaced with the Standard Terminal Replacement System (STARS), which is now under development.

The Common ARTS Program was developed in response to traffic growth throughout the NAS. All ARTS programs have a common air traffic control mission with similar functional requirements. Previous versions had been developed independently, with periodic upgrades of separate systems to add new features. The Common ARTS Program was designed to use identical commercial off-the-shelf (COTS) microprocessors and software to economically upgrade the dated ARTS IIA systems and to enhance the ARTS IIIE systems. The new ARTS systems share a common software baseline that can be adapted to the size and complexity of a facility. This permits the standardization of procedures, training, and logistics support.

The new systems provide modern COTS hardware (with the exception of the displays), more flexible systems architecture, and enhanced site adaptation capability. The new ARTS IIE versions support one or two sensors and up to 22 displays that can process 256 radar tracks per sensor, and have had Mode C Intruder alert capability added. The new ARTS IIIE version supports 15 sensors, over 200 displays, and can process 10,000 simultaneous radar tracks.

9.2 Free Flight Technology Operational Tests

Modernizing the NAS has inherent risks because many of the new technologies have not been operationally tested. To minimize these risks and to gain a better understanding of potential challenges, the FAA has developed two risk mitigation strategies: Free Flight Phase 1 and Safe Flight 21. These programs are intended to reduce technical and financial risks through the implementation of select technologies at specific sites for evaluation by NAS users and the FAA prior to full implementation.

9.2.1 Free Flight Phase 1

The Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD) initiative was designed to deliver early benefits of Free Flight to NAS users while mitigating the risks of implementing new technologies. Under this initiative, the FAA is evaluating five technologies: the User Request Evaluation Tool, the Traffic Manager Advisor, the Passive Final Approach Spacing Tool, the Surface Movement Advisor, and Collaborative Decision Making. Each of these technologies is described briefly below.

8 The HOCSR computers have been installed at the 20 en route centers and the three oceanic centers. The Phase 2 software was installed at 22 of the 23 sites by September 2000; the last site, Honolulu, will not go operational on the Phase 2 software until a new facility is commissioned in FY 2001.

User Request Evaluation Tool (URET)
Extracts real time flight plan and tracking data from the HOST computer, builds flight trajectories for all flights within or inbound to the ARTCC and identifies potential separation conflicts, up to 20 minutes in advance. URET will permit greater route flexibility within en route airspace by enabling controllers to more effectively manage user requests. The conflict detection capability will be especially useful in permitting user requests in oceanic airspace.

Traffic Management Advisor (TMA)
Provides en route controllers and traffic management coordinators with automation tools to manage the flow of traffic from a single center into selected major airports, with consideration given to separation, airspace, and airport constraints. Long term improvements include a TMA multi-center capability to enable multiple ARTCCs to meter arrivals into a single terminal, and a descent advisor, which will provide optimized descent point and speed advisories to controllers based on aircraft type.

Passive Final Approach Spacing Tool (pFAST)
Helps controllers select the most efficient arrival runway and arrival sequence within 60 nautical miles of an airport, considering aircraft type, speed, and trajectory. Active FAST (aFAST) will enhance pFAST capabilities by helping controllers determine how to vector aircraft onto final approach.

TMA and pFAST together constitute the Center Terminal Radar Approach Control Automation System (CTAS). CTAS combines the capabilities of these systems to help controllers efficiently descend, sequence, and space arriving aircraft within 200 nautical miles of an airport.

Surface Movement Advisor (SMA)
Promotes sharing of dynamic surface-related information among airlines, airport operators, and air traffic controllers in order to control the efficient flow of aircraft and vehicles on the airport surface. The system provides prediction capabilities to controllers to help them more efficiently manage operational resources and to optimize airport configurations. The Surface Management System (SMS), evolved from the SMA, will provide airport configuration, aircraft arrival/departure status, and airfield ground movement advisories to controllers, dispatchers, and traffic flow managers. The SMA, through more efficient coordination of information and enhanced management of ground support services, allows for faster aircraft turnarounds, reduced communications, fewer unnecessary diversions, and reduced taxi times and takeoff delays.

Collaborative Decision Making (CDM)
Both a philosophy of traffic management and an array of computer tools that facilitate a real-time collaboration between the FAA, and the airlines. CDM provides FAA traffic flow managers and airline dispatchers with the same real-time information. It links the FAA with the dispatch systems of the airlines and provides the airlines with access to NAS data, including weather, equipment, and delays. CDM allows the FAA to manage the air traffic system more efficiently and the airlines to employ their aircraft more effectively.

Figure 9-1
Free Flight Phase 1 Deployment Sites

Figure 9-1 shows the airports, TRACONs and ARTCCs where these technologies have been deployed. In the map, the United States is divided by the boundaries of the airspace managed by each center. The individual facilities where the FFP1 tools have been deployed are identified by symbols.

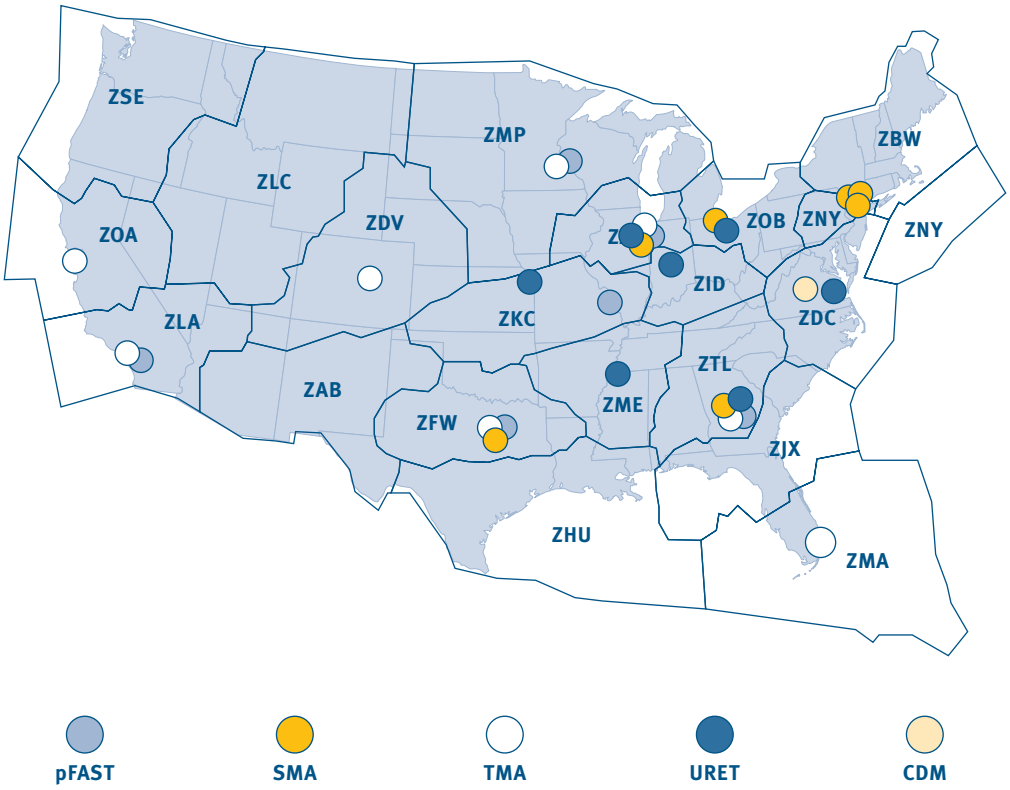


Figure 9-2 identifies the specific sites where each of the separate technologies have been deployed and the remaining sites under the FFP1 program. URET and TMA are deployed at ARTCCs, pFAST is deployed at TRACONs, and SMA is deployed at airports. The central functions of CDM are located at the Command Center, but other functions are located at the Volpe Center in Cambridge, Massachusetts and at traffic management units at the 20 ARTCCs and at selected TRACONs.

Figure 9-2
ATC Facilities with Current and Planned FFP1 Deployments

SMA at Airports	**URET** at ARTCCs	**TMA** at ARTCCs	**pFAST** at TRACONs
Atlanta	**Indianapolis**	**Atlanta**	**Fort Worth**
Detroit	**Memphis**	**Denver**	Atlanta
Indianapolis	Atlanta	**Fort Worth**	Chicago
Philadelphia	Chicago	**Los Angeles**	Los Angeles
Chicago	Cleveland	**Minneapolis**	Minneapolis
Dallas/Fort Worth	Kansas City	**Miami**	St. Louis
Newark	Washington	Chicago	
Teterboro		Oakland	

Deployed capabilities in bold

9.2.1.1 Results of Free Flight Phase 1 Deployment

The FFP1 program has been successfully implemented at all of its initially planned sites and has been extended to others. In addition, the new technologies are bringing real and measurable improvements.

- User Request Evaluation Tool prototypes have been deployed at Indianapolis and Memphis. Controller usage of the prototype continues to increase and to satisfy their requests, the FAA increased its availability from 16 to 22 hours per day in February 2000. URET has increased the number of direct routes at Indianapolis and Memphis by approximately 30 percent.
- Traffic Management Advisor is fully operational at the Ft. Worth TRACON. Early indications show that TMA has increased the arrival rate at Dallas/Fort Worth airport by five percent. Early prototypes are deployed at Denver, Miami, Atlanta, and Los Angeles centers.
- Passive Final Approach Spacing Tool is fully operational at the Ft. Worth TRACON. Initial analysis shows that controllers are able to add one or two arrivals per rush (a rush is a 30-minute period of concentrated traffic), of which Dallas/Fort Worth airport has eight per day. Site system tests of pFAST were completed at the Southern California and Atlanta TRACONs in April 2000. The FAA completed installation of pFAST at the Minneapolis TRACON in May 2000.
- The Surface Movement Advisor deployment has been completed on schedule and within budget. SMA has been in daily use at Philadelphia International and Detroit Metropolitan airports since December 1998. SMA became operational at Dallas/Fort Worth, Chicago O'Hare, Newark, and Teterboro airports in December 1999. An early version of SMA, which differs from the FFP1 systems, is being used at Atlanta Hartsfield. Northwest Airlines reports that SMA has helped them avoid three-to-five diversions per week at their Detroit hub during inclement weather.
- In Collaborative Decision Making, the FAA has completed Ground Delay Program Enhancement and Initial Collaborative Routing, two of the three basic elements that define CDM for FFP1. CDM to date has helped the FAA and the airlines avoid over 10 million minutes of delay. Special Use Airspace information became available to the CDMNet on June 1, 2000.

9.2.2 Free Flight Phase 2

The FAA recently prepared for the next phase of NAS Modernization by creating an office for Free Flight Phase 2 (FFP2). Free Flight Phase 2 builds on the successes of Free Flight Phase 1 to improve safety and efficiency within the NAS. FFP2 includes the east-to-west expansion of Phase 1 elements to other FAA facilities. FFP2 will also provide incremental enhancements to those elements during the period 2003-2005.

The full deployment of FFP1 capabilities will require support from other programs that provide improvements to the NAS infrastructure. The recent completion of the DSR and HOSCR programs are the first steps towards that goal. FFP2 will also develop several new Free Flight capabilities, which are described briefly below.

Collaborative Routing Coordination Tool
A set of automation capabilities that can evaluate the impact of traffic flow management re-routing strategies.

High Altitude Airspace Concepts
Will provide efficiencies in sectors above 35,000 feet at all FAA Air Route Traffic Control Centers.

Controller Pilot Data Link Communication (CPDLC)
Will allow voice messages to be replaced with data messages that are displayed in the cockpit. The initial version of CPDLC, Build 1, will use a combination of analog and digital data link technologies to provide an incremental step for implementing en route data links. CPDLC Build 1A, Build 2, and Build 3 will expand the message set to include additional key flight data and will eventually provide a fully integrated all-digital system.

9.2.3 Safe Flight 21

Safe Flight 21 is a five-year government and industry effort to demonstrate the capabilities of advanced communication, navigation, surveillance, and air traffic procedures associated with Free Flight. Safe Flight 21 expects to validate the modernization effort and accelerate its progress, while minimizing the long-term risks and costs. The Safe Flight 21 initiative will focus primarily on developing a suitable avionics technology, pilot procedures for air-to-air surveillance of other aircraft, and a compatible ground-based automatic dependent surveillance system for air traffic control facilities. The Safe Flight 21 initiatives will demonstrate the usefulness of two new technologies, which are described below.

Automatic Dependence Surveillance-Broadcast (ADS-B)
A surveillance system that continuously broadcasts GPS position information, aircraft identification, altitude, velocity vector, and direction to all other aircraft and air traffic control facilities within a specific area. ADS-B information will be displayed in the cockpit via a cockpit display of information (CDIT) unit, providing the pilot with greater situational awareness. ADS-B transmissions will also provide controllers with a more complete picture of traffic and will update that information more frequently than will other surveillance equipment. On the surface, ground vehicles can also use ADS-B to be visible to, and to see, taxiing aircraft.

Traffic Information System-Broadcast (TIS-B)
A communications system that will transmit traffic and other information available on the ground to the cockpit. TIS-B will also provide pilots with greater situational awareness.

The Safe Flight 21 program will also quantify operational benefits, demonstrate capabilities, and collect data on the performance of three candidate data link technologies for air-to-air surveillance: Mode Select (Mode S) Extended Squitter, Universal Access Transceiver, and VHF Data Link (VDL) Mode 4.

Safe Flight 21 demonstration projects have been initiated at two sites: in the Ohio Valley in collaboration with the Cargo Airline Association and in western Alaska with commercial aircraft providing passenger, mail, and freight services. A common design is being used for the two project sites to facilitate the collection and analysis of data.

9.2.3.1 Ohio Valley Project

Safe Flight 21's Ohio Valley Project is testing ADS-B avionics on commercial cargo aircraft in the Ohio Valley. These tests are taking place in terminal areas with significant cargo operations, including Memphis, Tennessee; Wilmington, Ohio; Louisville, Kentucky; Scott Air Force Base, Illinois, and Nashville, Tennessee. The Ohio Valley Project is co-sponsored by the Cargo Airline Association (CAA) and the FAA. The CAA has purchased, equipped, and is maintaining the avionics for the test aircraft. The CAA members are conducting revenue flights with these aircraft to evaluate the systems' performance in normal operations.

The FAA has purchased, installed, and is maintaining ground systems at the five sites. A ground broadcast server has been installed at the Wilmington site that receives data from the other sites and depicts ADS-B targets fused with radar targets. As the project proceeds, fused ADS-B and radar target data will be made available to suitably-equipped aircraft to enable the pilots to see both targets on a cockpit display, along with selected broadcast information such as weather maps, special use airspace status, and wind shear alerts.

The Ohio Valley Project is being assessed in a series of Operational Evaluations. The first evaluation demonstration took place in July 1999 at the Wilmington site. It concentrated on measuring the improvement in the test aircraft's ability to make approaches in low visibility conditions and their enhanced ability to see-and-avoid adjacent traffic. Cargo carriers, the FAA, NASA, the military, and academia participated in this initial evaluation. During the demonstration, aircraft equipped with ADS-B enabled pilots to consistently maintain close separation.

The second operational evaluation is scheduled for October 2000 at the Louisville site, with as many as 20 aircraft expected to participate. CAA members have committed eight aircraft and other aircraft from NASA, the U.S. Navy, and the Aircraft Owners and Pilots Association are expected. The third operational evaluation is scheduled for the Memphis site in May 2001.

9.2.3.2 Alaska Capstone Program

The Capstone Program was developed by the FAA in response to an NTSB safety study, Aviation Safety in Alaska, to address Alaska's high accident rate for small aircraft, which is five times the national average. The principal objective of the Capstone Program is to improve pilots' situational awareness of the flight environment and to thereby avoid mid-air collisions and controlled flight into terrain. A recent FAA-sponsored study estimated that 38 percent of commercial operator accidents in Alaska could be avoided if information on position relative to terrain and real-time weather information were available to pilots in the cockpit. The Capstone Program will attempt to validate these safety projections.

The FAA will equip up to 150 commercial aircraft in a non-radar environment in the Yukon-Kuskokwim Delta region of southwest Alaska with the Capstone avionics suite.[9] It includes a cockpit multifunction display, a GPS navigation/communications unit, a Universal Access Transceiver datalink unit, and a GPS-based terrain database of Alaska. The suite enables each participating aircraft to broadcast its identification, position, altitude, climb rate, and direction and to receive similar signals from other aircraft.

The FAA will install a network of 12 data-link ground stations that will transmit radar targets of non-participating aircraft to the Capstone aircraft. In addition, the ground stations

9 The FAA recently issued a supplemental type certificate for a Capstone avionics package. The STC provides the necessary authorization to install the avionics in 23 types of small aircraft that will be used in the Capstone demonstrations.

will transmit flight information services, including weather reports and forecasts, maps, status of special use airspace, pilot reports, and notices to airmen. The FAA is also publishing non-precision approaches and installing automated weather observation systems at ten village airports in the Delta region.

The University of Alaska Anchorage (UAA) is conducting training sessions for Capstone as well as conducting an in-depth safety study and assessment of Capstone. UAA will train a cadre of instructors who will in turn conduct individual company training. The training program began in Bethel, Alaska in early February 2000 and will continue until each participating commercial company has at least one fully-trained instructor and a complete set of Capstone modules with reference library materials. The safety study will assess the benefits of the Capstone avionics and the use of new flight procedures.

The initial improvements of Capstone are directed towards pilots conducting VFR operations. In the future, the FAA plans to certify systems and equipment and develop enhanced operational procedures for IFR operations. When this is accomplished, ADS-B can be used for air traffic control functions just as radar is now used.

9.2.4 Other Modernization Programs

Each phase of NAS Modernization has programs that will affect each operating environment. Figures 9-3 through 9-5 identify the evolutionary programs of NAS Modernization by time and phase of flight, providing an overview of the time line as well as the relationships among programs.

Figure 9-3
NAS Modernization Phase 1 (1998-2002)

Phase of Flight	Key Event	Capability
Operational Planning	Deploy initial CDM to increase the electronic exchange of information between the airlines and the FAA, as part of Free Flight Phase 1.	Increases collaboration between the FAA and airlines allowing for more flexibility in planning operations.
	Begin deployment of OASIS.	Resolves critical hardware supportability issues and improves available information displayed to the flight service specialist.
Airport Surface Operations	Continue commissioning of ASDE-3 with AMASS to increase detection of aircraft and vehicles on runways and taxiways at the 34 busiest airports.	Increases safety by reducing the probability of collisions and increasing the controllers' situational awareness.
	Deploy SMA at selected airports as part of Free Flight Phase 1.	Provides aircraft arrival information to airline ramp operators/managers.
Departures/Arrivals	Achieve initial WAAS terminal navigation and precision approach capability.	Provides satellite-based navigation, more precision approaches, and supports terminal area low-altitude direct routing which increases safety and capacity in a limited area.
	Deploy STARS.	Resolves supportability issues and provides a color display to TRACON and tower controllers.
	Deploy CTAS pFAST at selected TRACONs as part of Free Flight Phase 1.	Provides initial controller tools to improve arrival spacing and runway assignments.

Phase of Flight	Key Event	Capability
Departures/Arrivals *continued*	Deploy ITWS stand-alone to selected airports.	Improves windshear alert and hazardous weather information reporting to controllers.
	Deploy digital radar.	Installs new digital airport surveillance radar (ASR-11) for better aircraft and weather detection.
En Route/Oceanic	Achieve initial WAAS en route navigation capability.	Provides satellite-based capability for en route navigation.
	Implement weather on DSR to enable NEXRAD data to be displayed to en route controllers.	Increases the safety of the NAS (hazardous weather avoidance) and allows certain primary long-range radar to be decommissioned.
	Authorize air-to-air ADS-B self-separation procedures in specific situations, such as oceanic passing maneuvers.	Increases operations efficiency by utilizing cockpit surveillance capability.
	As part of Free Flight Phase 1 effort implement as selected sites: • URET CCLD • CTAS TMA single center	Enhances the efficiency of the en route operations: • Helps controllers determine the feasibility of user requested route and altitude changes • Improves arrival sequence planning
	Provide initial FIS to the cockpit.	Increases availability of weather and aeronautical information to the cockpit for properly equipped aircraft.
	Initial multi-sector oceanic data link in all oceanic facilities.	Enables oceanic controller to exchange data messages with FANS-1/A-equipped aircraft.
	Deploy digital radar.	Installs new digital en route air traffic control beacon interrogator radar (ATCBI-6) for better aircraft detection with selective interrogation capability.
Operational Planning	Implement flight plan evaluation to increase collaboration with users.	Increases collaboration between the FAA and airlines allowing for more predictability to NAS operations.
Airport Surface Operations	Deploy runway incursion reduction capability at smaller airports to increase the detection of aircraft and surface vehicles.	Increases safety by reducing the probability of collisions and increasing controllers' situational awareness.
	Deploy SMS providing controllers tools to improve surface traffic movement operations.	Provides sequencing and runway information to the AOCs at larger airports.
Departures/Arrivals	Implement TIS on Mode-S to provide traffic information to pilots via Mode-S data link.	Increases situational awareness for pilots of TIS-equipped aircraft by displaying nearby traffic.

Figure 9-4

NAS Modernization Phase 2 (2003-2007)

Figure 9-4

NAS Modernization Phase 2 (2003-2007) – *continued*

Phase of Flight	Key Event	Capability
Departures/Arrivals *continued*	Provide full WAAS terminal navigation and precision approach capability.	Provides satellite-based navigation, more precision approaches, and supports terminal area low-altitude direct routing without restrictions.
	Deploy LAAS CAT I/II/III capability.	Increases the number of precision approaches within the NAS.
	Complete STARS deployment with planned improvements.	Resolves supportability issues and provides TRACON controllers decision support tools for traffic control and planning.
	Complete pFAST national deployment.	Provides controller tools to improve arrival spacing and runway assignments.
	Provide improved weather on STARS at selected airports.	Improves windshear alert and hazardous weather information reporting to controllers.
En Route/Oceanic	Provide terminal surveillance with ADS-B information on STARS.	Provides more accurate aircraft position by integrating ADS information on controller displays.
	Deploy full WAAS en route navigation capability.	Provides satellite-based capability for en route navigation without restrictions.
	Deploy ADS-B gap-filler (passive listening stations) to provide surveillance for areas that currently are not covered by radar.	Provides surveillance services to ADS-B equipped aircraft rather than procedural separation.
	Deploy en route CPDLC Build 2.	Expands message set to reduce voice congestion in high-density traffic areas.
	Implement ADS-A for oceanic surveillance.	Enables controllers to reduce separation between aircraft and grant user requests for fuel efficient altitudes.
	Deploy NEXCOM radios and begin use of digital voice capability in high-altitude en route sectors.	Relieves frequency congestion problems for voice services and provides for clear communications.
	Deploy conflict probe nationally.	Enables controllers to grant user requests based on information that is available across center boundaries.
	Deploy multi-center metering with descent advisor to assist traffic managers and controllers.	Improves the arrival sequencing across multiple centers to congested airports.
	Provide 50/50 nautical mile separations between aircraft in oceanic airspace.	Allows FANS-1/A and ATN-equipped aircraft to fly optimum routes over the ocean.

Phase of Flight	Key Event	Capability
Operational Planning	Implement NAS-wide information sharing and full CDM.	Allows common data exchange for flight planning and traffic flow purposes.
	Provide interactive airborne refile to enable increased collaboration with users.	Provides in flight automated exchange and processing of flight plan change requests between pilots and controllers for route clearances.
Airport Surface Operations	Provide integrated tower area surveillance for tower and surface.	Provides tower and TRACON controllers improved surveillance based on ADS-B
	Deploy enhanced SMS.	Improves planning and coordination of arrival/departure and surface operations.
Departures/Arrivals	Transition selected terminal areas to digital communications via NEXCOM (VDL-3) and CPDLC for voice and data exchange among controllers and pilots.	Relieves spectrum congestion problems and allows pilots and ATC to directly exchange messages in the terminal environments.
	Deploy aFAST with wake vortex at TRACONs.	Provides better sequencing, spacing, and runway assignment of aircraft on final approach to congested aircraft.
En Route/Oceanic	Improve en route surveillance with ADS-B.	Provides more accurate aircraft position by integrating ADS information on controllers displays.
	Transition to a NAS-wide data link via full NEXCOM (VDL-3) and CPDLC at all high-altitude sectors.	Relieves spectrum congestion problems and allows pilots and ATC to directly exchange messages in the en route environment.
	Use conflict resolution with multi-center metering to evaluate requested flight path amendments across center boundaries.	Increases ATC capability to accommodate changes to the flight while in flight.

Figure 9-5

NAS Modernization Phase 3 (2008-2015)